THE GAS JOURNAL

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EDITORIAL NOTES

Institution Week

THE early publication of the programme for Institution Week—the 71st Annual General Meeting—which we were able to include in our columns a fortnight ago, will have given members ample opportunity of contemplating the crowded events of four days in June. According to his nature or his mood, the individual general meeter will have pondered upon the amount of information he is likely to be able to absorb from no fewer than eight papers and discussions, upon the chances of his being presented with a souvenir Ford car if he takes part in the Dagenham visit, or upon his wife's visits to the West End shops while he is absorbing information, and the consequent possible uses of Beachy Head at the end of the Sussex Tour. At any rate, one thing we can safely say is that London is the most popular of all meeting places.

In more serious vein, we must congratulate those who have had the responsibility of arranging the meeting, firstly, upon the admirable organization. As we read the programme through, it is difficult to visualize the amount of detail work which has been involved in mapping out our every hour, and from the experience of recent years we feel sure that we shall look back afterwards upon crowded days certainly, but not muddled ones. Secondly, though naturally at this stage we must withhold comment upon the contents of the papers, no one can disagree with our view that the subjects covered are of first-rate interest to the Gas Industry of to-day, and that they are by authors whose views on these subjects are bound to carry weight. From these, and from the Address of a President of such wide experience as Mr. F. P. Tarratt, there will be few who cannot derive inspiration upon some pressing problem of the present or of the immediate future.

By the courtesy of the Institution we are able again this year to publish, in advance of the Meeting, the bulk of the contributions to be presented. And it is indeed a bulk. In years gone by the length would have appalled us, and we should have visualized session overlapping into session, the while a harassed President would endeavour tactfully to call the attention of the readers to the clock. Now this lengthy, unnecessary reading of papers by their authors has wisely been abolished—one of the best moves made by the Institution—and the introduction of the speakers' indicator has had a chastening effect all to the good of the discussions as a whole. The discussions in this instance cannot fail to be of the greatest use to the Industry, and we believe that our Institution Number at the conclusion of the meeting containing a full report of them, together with this present issue, will show the 71st Annual General Meeting to have been one of the most valuable of all the series.

Further Thoughts on the B.I.F.

WE had thought that the recommendation of the Gas Industries Section Committee that no official gas section be organized by them next year at the British Industries Fair would dispose of the matter at any rate as far as 1934 is concerned. When discussing the question on several occasions, we have made it clear that an examination of all the factors involved led us to believe that the chances of a successful gas show at Castle Bromwich next year would be remote, in view of the change of date to May. Then there was an offer of space at the Olympia Section, still to be held in February, which was by general consent unsuitable, and turned down without need for much hesitation.

All along, however, we have been well aware of a very strong feeling in some quarters that every possible effort should be made not to abandon the very strong position which the Industry has undoubtedly built up for itself at the British Industries Fair, and that it will be difficult to find any adequate and satisfactory substitute for representation in what is, after all, a nationally organized exhibition in the true sense of the word. We understand that an appeal has now been made to the Gas Industries Section Committee to think just once again on these lines; and that the appeal has support which the Committee cannot well ignore. It has, we believe, been put to them with full recognition of the difficulties which have arisen owing to the altered date, and an acknowledgment that financial considerations must of necessity be weighed up principally by those who pay.

We well understand the fear that it may possibly be short-sighted on the part of the Industry to drop out entirely, because the transition from an apparently flourishing demonstration in one year to nothing at all in the next appears sudden and drastic. We believe that the Committee, on which, after all, various opinions have already been listened to, had given the whole matter the most careful consideration before coming to their decision, but they will no doubt give yet another hearing to the strong representations which have now been made to them. We have set forth, in this and in previous discussions of the matter, the principal considerations which appear to us material, and we can only urge once again the importance of having either a first-class show or none at all. Much better, to our mind, the dropping altogether of participation than a half-hearted and disjointed effort taking the place of the well organized shows of recent years, rendered so forceful by co-operation, and enthusiastic by the holding of united Conferences. We ask that full consideration be given to this view both by those who are still anxious that an exhibit at the B.I.F. be continued in some shape or form, and by those who

have been asked to reconsider their decision against exhibiting. If they feel that something really good can still be accomplished, well and good. If not, then let us all turn our minds to finding an efficient substitute for future years.

Modifications and Repairs

THE Address which Mr. F. P. Fall, of the Sunderland Gas Company, delivered on Saturday last as Chairman of the Auxiliary Section of the North of England Gas Managers' Association is concerned with certain modifications carried out in recent years to the Hendon Works and with extensive repairs to gasholders there. The first part of the address exemplifies how one thing leads to another. The installation of a waste-heat boiler on a horizontal retort bench five years ago has enabled several important developments to be effected. Resulting from its introduction a battery of three Lancashire boilers which had arrived at a stage when the cost of repairs and maintenance was excessive, and which, moreover, were unsuitable for working pressures over 80 lbs. per sq. in., was thrown out of commission. This, in turn, afforded an opportunity of centralizing the power plant at the works—a scheme at present in course of fulfilment, and which will make for a much higher efficiency of works operation. Then, arising out of this centralization of power, a system was developed for the collection of exhaust steam for heating softened boiler feed water by indirect contact.

Readers will be interested in Mr. Fall's reference to the plant at the Hendon Works for recovering the combustible matter from pan ashes. This plant separates the coke from the clinker in a dry state, the operation being effected by electro-magnetic attraction on the principle that, while the iron compounds in the clinker are susceptible to magnetic influence, the coke is not. A full description of the plant was given by Mr. Fall in the "JOURNAL" for June 6, 1928; and in his present address he states that after nine years' working the plant is still capable of giving 95% separation efficiency, while the renewal of wearing parts is not a costly item. The section of the address dealing with gasholder repairs is also full of interest, for the Hendon Works are built on a barrier between two collieries, and although actually on solid ground the draw from the adjacent workings is sufficient to account for considerable structural disturbance. Mr. Fall gives an account of repairs to two holders, one of which was erected in 1861 and the other in 1871. These holders were constructed of puddled wrought iron; and he concludes his address by expressing the doubt whether mild steel working under similar conditions would approach anything like such an age, and by mentioning that quite a number of gasholders constructed in mild steel have been re-sheeted after working less than thirty years.

A Standard Bath?

GOOD salesmanship has plenty of chances in the Gas Industry, and, as we have emphasized, the domestic hot water field offers great opportunity. Now is the time to concentrate on this load, when kitchens are becoming overheated by coke boilers constantly in operation to afford the necessary service. Of course, care must be exercised in advising on the type of apparatus which will give the greatest satisfaction. The whole science of salesmanship in the water heating field is to install the appropriate appliance for each individual situation, confident in the knowledge that we can accomplish with gas what cannot be accomplished by solid fuels or at all easily by electricity. This requires a study of people and their habits, as well as thorough knowledge of the appliances available and the demands which they can satisfy.

The gas circulator, instantaneous heater, and storage heater have been developed to a high degree of efficiency and a high standard of finish. Each has its special advantages and special sphere, and the satisfaction of the consumer depends upon whether the salesman gives the right advice in the light of the particular circumstances. So many factors enter into the problem of estimating the amount of water required for baths that its solution is not easy. As we have said, the habits of the consumer must be taken into account—the number of baths needed per day, and at what times; whether the load is spread out over the day or is a peak load necessitating either considerable storage capacity or an instantaneous heater. Speed of recovery of storage water heaters must be a primary consideration, and an adequate supply of really hot water should be ensured.

Nor is the problem simplified by the wide diversity in sizes of baths. Baths differ greatly in capacity, and a heater quite adequate for a small bath may prove unsatisfactory if it is fitted to serve a large one. The size of the body may have a bearing on the matter, but we will not discuss that here. We cannot standardize bodies, which is highly unfortunate, for size affects so many facets of comfort, but we can do much to standardize baths. This week builders' merchants throughout the country have received from the International Bath Association a letter giving them a few details of a new standardized bath, and promising full details in a month. A similar letter has also been addressed to all housing authorities. What we already know about the bath—which has been specially devised for housing schemes and small houses generally—is that it uses less water, although the effective length of the bath is greater, and that its other attractive points should appeal to householders as well as to builders. This new bath is of decided interest to the Gas Industry, for its adoption would obviously facilitate estimating for hot water requirements, and its capacity would still further favour the use of gas.

Coke Oven Gas

DISCUSSING the question of coke oven gas for town supply in the "JOURNAL" last week we said that a gas undertaking cannot be dependent on the supply of coke oven gas from a single coking plant. In this connection we inadvertently implied that this was the view of Dr. E. W. Smith. In a letter published to-day, however, Dr. Smith makes it clear that what he intended to convey in his contribution to the discussion on Major Koopman's paper was that this was the opinion of gas undertakings in the past. He was, in fact, not expressing his own ideas on the subject, which are brought out in his letter. "It is well known to many of us," he observes, "that many gas undertakings have taken coke oven gas from single batteries of ovens for some years with much satisfaction. . . . One of the difficulties which is raised by some gas undertakings is that they hesitate to take gas from isolated coke oven plants. Nowadays there is little to fear in this respect."

It would be unfortunate if our comments in the "JOURNAL" last week should make gas undertakings more hesitant to take coke oven gas. Such was certainly not our intention. Lest confusion should arise over our use of the word "dependent" we will define this. By "dependent" we intended to convey that the gas undertaking would have no stand-by plant. Clearly, if an undertaking has stand-by plant, then it is not dependent on coke oven gas supply. And we should be glad to have information of those gas undertakings not having stand-by plant who are taking coke oven gas from single batteries of coke ovens.

Forthcoming Engagements.

May 31.—B.C.G.A.—Yorkshire District Conference at Harrogate.
June 1.—B.C.G.A.—Eastern District Conference at Lincoln.
June 5-8.—I.G.E.—Annual General Meeting, London.
June 14.—S.B.G.I.—Council Meeting, 11.15 a.m.
June 16.—LONDON AND SOUTHERN JUNIOR ASSOCIATION.—Summer Visit to Hastings.
June 20.—B.C.G.A.—Meeting of Executive Committee, 12 noon.
June 29.—WAVERLEY ASSOCIATION OF GAS MANAGERS.—Annual Meeting in Edinburgh.
July 7.—WESTERN JUNIOR ASSOCIATION.—Summer Meeting.
Sept. 6.—NORTH BRITISH ASSOCIATION OF GAS MANAGERS.—Annual Meeting in Inverness.

PERSONAL

SOUTHPORT'S NEW GAS ENGINEER.

Mr. J. Herbert Clegg, A.M.I.Mech.E., Engineer and Manager of the Burnley Corporation Gas Department for the past ten years, has been appointed Engineer and Manager of the Southport Corporation Gas Undertaking, in succession to Mr. John Bond, O.B.E., who retires from office in June.

Mr. Clegg was formerly Deputy Engineer and Manager at Burnley for five years, and succeeded Mr. J. P. Leather, M.Inst.C.E., on his retirement early in 1924. He has also

MR. J. H. CLEGG.

been engaged in various capacities with the Earby and Thornton Gas and Lighting Company, the Nelson Corporation Gas Department, the Aldershot Gas, Water and District Lighting Company (now the Mid-Southern Utility Company), and the Blackburn Corporation Gas Department.

At Burnley, Mr. Clegg was responsible for the design and erection of a completee new gas-works at Oswald Street, involving a capital expenditure of over £300,000. These works were formally opened by the late Sir Richard Threlfall, G.B.E., F.R.S., in 1928. They also formed the subject of a paper which Mr. Clegg presented to the Institution of Gas Engineers in 1931.

In 1929-1930 Mr. Clegg inaugurated the addition of a supply of coke oven gas from the Altham Coke Ovens, which involved the laying of a high-pressure main, largely above ground, for a distance of seven miles, and the provision of plant, involving an additional expenditure of £60,000, to enable the old uneconomical works at Parker Lane to be scrapped. During the ten years Mr. Clegg has occupied his position, the net profits have averaged £13,000 per annum, although the price of gas has been reduced to produce an average income of 6·384d. per therm.

Mr. Clegg is on various Committees connected with the Gas Industry, including District Vice-Chairman of the British Road Tar Association, and Vice-Chairman of the temporary Committee engaged in the constitution of the new Manchester and District Industrial Gas Centre.

* * *

Alderman Joseph Edward Cox, J.P., who has been Chairman of the West Bromwich Gas Committee for fifteen years, has been presented with the freedom of the County Borough of West Bromwich in recognition of the long and valuable services rendered to that borough as a member of the Council since 1904, and in the cause of education for 35 years. The present of a book engrossed and illuminated on vellum was enclosed in the polished rosewood base of a silver casket surmounted by the borough arms handsomely chased. Alderman Cox is the father of Mr. F. E. Cox, Engineer and Manager to the Newport (I.O.W.) Gas Company.

* * *

Major Charles Whitford Leake, of Wellington (Salop), celebrated his 80th birthday on May 23. Mr. Leake is head of Leake's, Ltd., proprietors of the *Wellington Journal and Shrewsbury News*, and is also prominently connected with other business concerns in the town. He has been associated with the Wellington Gas Company for over 40 years and has been Chairman since 1917. He still attends regularly to his duties at the Head Office of the newspaper at Wellington and he has received many congratulations on attaining his 80th birthday.

* * *

Mr. G. T. Joyce, who has been in the service of Messrs. Alexander Duckham & Co., Ltd., for 27 years, has been appointed Manager of the Industrial Oil Sales Section.

OBITUARY

The death took place at Thornton on May 19 of Mr. William Rogerson, in his 53rd year. Mr. Rogerson recently retired from the position of Gas Engineer and Manager to the Middleton Corporation, and up to the time of his death was Chairman and Managing Director of the Fleetwood Gas Company. He was also a Director of the Kirkham Gas Company. Deceased had been in poor health for some considerable time.

* * *

France has recently lost another of her leading gas engineers by the death at the age of 82 years of M. Henri Marquison, a Past-President of the Société Technique de l'Industrie du Gaz en France.

* * *

Mr. James Johnstone, Solicitor, of Moffat, who was Secretary and Treasurer of Moffat Gas Company, has died at his residence in Moffat.

CORRESPONDENCE

Who Sells the Cheapest Gas?

Sir,—In evidence during the proceedings of the Sheffield Gas Bill before the House of Lords Committee (p. 469 of your issue for May 23) it was stated that "the Company's basic rate was 7d. per therm and, with the exception of Bath, it was the cheapest rate charged anywhere in the country."

We have for long past prided ourselves that we in Middlesbrough occupied the premier position in the country in regard to price. At the present time this is 4·7d. per therm, less 10% discount for cash, equal to 4·23d. net or 1s. 9·15d. per 1,000 c.ft.; and if there is a lower price anywhere else we shall be glad to have the information.

Yours, &c.,

Charles F. Blincoe,
Engineer and Manager.

Corporation Gas-Works,
Commercial Street, Middlesbrough,
May 28, 1934.

"International Coal Carbonization."

Sir,—I feel sure that Dr. J. G. King in his review of the above book by Dr. Jenkner and myself had no intention other than to be fair and generous to the authors, but he has left the impression that certain researches have been overlooked, whereas in fact they have not. For instance, Ryan's work is referred to on p. 389, and that of Burke, Schumann, and Parry on p. 140. Reference to the Fuel Research Board experiments on horizontal gas retorts will be found on p. 231, in connection with the employment of high velocities of the heating gases in retorting and in boiler practice.

Dr. King states that "there is no mention of the use of active carbon for benzole recovery," yet the Beckton plant for the extraction of benzole by the activated carbon process is described and illustrated on pp. 328 and 329, under the heading "Benzole extraction by activated carbon."

I am not quite sure what Dr. King means when he states that there is no mention of the Fuel Research Board car-

bonizing process. Surely he does not mean the process which was employed at Richmond, but is now abandoned? It is known that the F.R.B. now recommends the employment of medium temperatures, as mentioned on p. 197; but if Dr. King means by the "Fuel Research Board Process" the manufacture of semi-coke from blends of coking and non-coking coals at medium temperatures, he will find that the process is fully described in the text, and the patent literature cited—for example, pp. 131-133, 136-137, and 391-392.

The work done by the Fuel Research Staff has not been overlooked. On the contrary, no fewer than 24 references to their work will be found in the book.

It is true that the treatment of bye-products is not dealt with as fully as in certain other publications, and in these days of specialization this is best left to specialists in that line, who can be relied upon to see that that side of the industry is not neglected. Our main purpose has been to deal with the subject of carbonization.

Yours, &c.,
JOHN ROBERTS.

5, *Victoria Street*,
Westminster, S.W. 1,
May 28, 1934.

Coke Oven Gas.

SIR,—In a leading article of the current number of the "GAS JOURNAL" you inadvertently make it appear that I am of the opinion that gas undertakings cannot be dependent on the supply of coke oven gas from a single coking plant.

I hasten to correct this obvious misconception, as it is well known to many of us that many gas undertakings have taken coke oven gas from single batteries of ovens for some years with much satisfaction.

In my contribution to Major Koopman's paper, I intended to convey that one of the difficulties which is raised by some gas undertakings is that they hesitate to take gas from isolated coke oven plants. Nowadays there is little to fear in this respect. Most coke ovens are as reliable as gas making units as those installations working on gas-works, and as most of them are manned by operatives unconnected with the colliers' unions there is no reason to believe that labour troubles will be any greater on coke ovens than in other important industrial enterprises.

Yours, &c.,
E. W. SMITH.

Ebury and Allington Houses,
136-150, *Victoria Street, S.W.* 1,
May 25, 1934.

THE NEWS OF THE WEEK

A Revised Syllabus of the Graduates' and the Associate Members' Examinations of the Institution of Heating and Ventilating Engineers has been issued and is obtainable from the Secretary of the Institution, 12, Russell Square, London, W.C. 1.

Distribution Engineer Required in Australia.—Applications are invited for the position of Distribution Engineer for a gas undertaking in Australia at a commencing salary of £550 per annum. Further particulars will be found in our advertisement columns.

Low Temperature Carbonisation, Ltd., in view of the continued demand for "Coalite," are to put up an eighth battery of retorts at Askern. This new extension means a total addition of 72 retorts to the Askern plant this year, making altogether 288 retorts for the completed plant.

Cookery Demonstrations at Chester.—A successful series of cookery demonstrations were held recently in the showrooms of the Chester United Gas Company, Northgate Street. Miss Gwen L. Hughes, of the Parkinson Stove Company, gave the demonstrations, and a large number of orders and inquiries were received.

A Report Presented by the Exeter City Council's Inspector of Gas Meters (Mr. E. M. Foster) shows that 43,880 meters were tested locally during the past year, the number rejected being 2,940, or 6·7% of the total tested. The fees paid amounted to £3,108 3s., and after meeting the expenditure there remained a credit balance of £2,099 19s. 3d.

Montevideo Gas and Dry Dock Company.—The Directors of this Company will recommend at the Ordinary General Meeting, to be held on June 12 next, a dividend of 3%, free of tax, for the year 1931, payable on July 6, to the stockholders on the register on May 30, 1934. This amount is provided by the amortization of Uruguayan Sterling Bonds held by the Company.

Technical Education in Welding.—Some time ago an Advisory Committee on Welding was established by the City and Guilds of London Institute, the body comprising among others, representatives of the Institution of Mechanical Engineers, Institution of Welding Engineers, the Board of Education, and several technical institutions and associations. The Advisory Committee has recently recommended and the Institute has adopted a scheme for examinations in the subject of electric arc and also oxy-acetylene welding, and full particulars of the new examination scheme can be obtained from the Institute, 31, Brechin Place, South Kensington, S.W. 7.

Wm. Cory & Son, Ltd.—The Directors of Wm. Cory & Son, Ltd., will recommend in respect of the year ended March 31, 1934, at the Annual General Meeting to be held on June 21, a final dividend of 10%, less tax, on the ordinary and employees' shares, making a total distribution of 15%, less tax, for the year, and a proportionate dividend on the employees' shares ranking for dividend from Jan. 1, 1934.

City and Guilds of London Institute.—The Department of Technology of the Institute has issued the Regulations and Syllabuses for Examinations in Chemical, Metallurgical, and other Allied Subjects for the session 1934-35. The booklet is published at 1s. (1s. 2d. by post) and is obtained from the Superintendent, Department of Technology, City and Guilds of London Institute, 31, Brechin Place, S.W. 7.

Institution Visit to Edmonton.

In connection with the forthcoming Institution visit to the Gothic Works of Messrs. Glover & Main, Ltd., Edmonton, it is interesting to note that the firm had already attracted considerable public attention as far back as 1898—before their move to Edmonton—less enlightened days when the efficiency of a workshop and the conditions of the workpeople were of little interest to the consumer of the goods produced. In a profusely illustrated article, "Lesser Columbus," writing in *Commerce* at that time, devoted over fifteen pages to an illustrated account of their activities. He began by a review of the history of the firm since its establishment in the "'forties." This included an account of the early attempts to measure gas with some degree of accuracy by Clegg, "who came to the conclusion that if he could have a twin pair of tanks, one of which could supply gas to the consumer, while the other was filling with gas, he could, by a recording apparatus, give a very fair estimate of the actual amount used by a consumer." Later in the article we read of the introduction of the leather diaphragm and of an efficient set of valves invented by the late Mr. Thomas Glover. Then came the difficulties associated with the production of the first prepayment meter. The author concluded with the remark that, whether the meters "are used for measuring the gas that is needed for illuminating one's dwelling or for heating the stoves, the meters sent out by the Clerkenwell firm maintain the reputation that the house has made for itself."

THE NEWS—*continued.*

SIR ARTHUR DUCKHAM MEMORIAL FUND

Official List of Donations from May 19 to May 25

The Committee hope to be in a position to endow a "Duckham Research Award," to be applied for the period and purpose of specified investigations of interest to the Gas Industry, at places, at home or abroad, selected as being appropriate for the conduct of each particular investigation. Subscribers, therefore, are not only paying a tribute to the memory of Sir Arthur Duckham, but are also assisting to strengthen the Gas Industry at a critical period of its development.

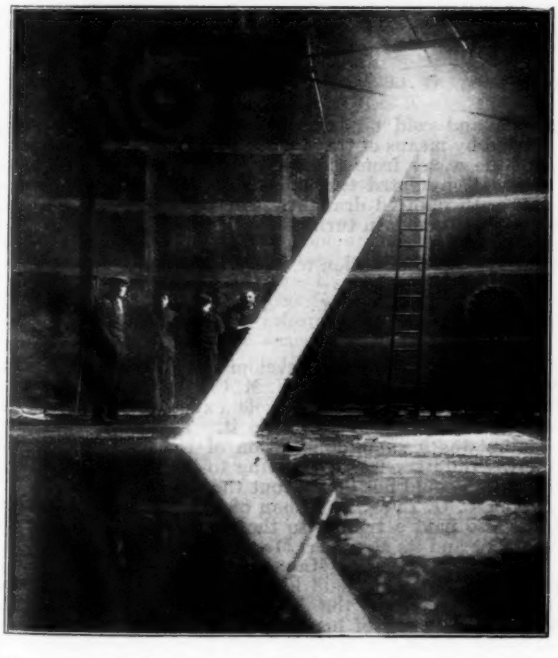
Name and Town.	Amount. £ s. d.
S. Langford, London	1 0 0
North Shore Gas Company, Ltd., North Sydney	10 10 0
City of Nottingham Gas Committee	10 10 0
Dr. Charles L. Reese, Delaware	4 16 8
C. Singleton, Sydney	5 5 0
Stafford Corporation Gas Committee	5 5 0
Swindon United Gas Company	5 5 0
Wales and Monmouthshire Association of Gas Engineers and Managers	2 2 0
C. & W. Walker, Ltd.	5 5 0
Woodall-Duckham (Australasia) Proprietary, Ltd.	50 0 0
Woodall-Duckham Companies; Directors and Staff (Third Donation)	50 0 0
Donations (11) paid above	£ 149 18 8
Donations (566) paid previously	9,452 9 6
Total Donations (577) paid	£9,602 8 2
Donations (9) promised	621 7 0
Total Donations (586) paid or promised	£10,223 15 2

New Scale of Charges at Saltcoats.

The Saltcoats Gas Company, Ltd., are introducing a new scale of reduced charges for ordinary consumers, to operate after the May survey.

			s.	d.	
First	5,000 c.ft. per quarter will remain at		3	9	per 1000 c.ft.
Next	20,000	will be at	3	4	" "
Next	25,000	" "	2	11	" "
All over	50,000	" "	2	6	" "

A Little Ray of Sunshine.



The accompanying photograph, for which we are indebted to Mr. Leonard Bott (Gasholder and General Gas Plant Inspector), of Granville Villas, Newport, Salop, is of an unusual nature. It was taken inside a holder which he was engaged in inspecting, and shows a ray of sunshine entering through the top manhole and reflected in a little water remaining in the bottom of the tank. An interesting point is the secondary reflection back off the surface of the water through the misty atmosphere which was not visible to the naked eye at the time.

South-Eastern Gas Corporation.

Offer for Chertsey Stock Accepted.

The South-Eastern Gas Corporation's offer to holders of ordinary stock of the Chertsey Gas Consumers' Company has been accepted by a large majority.

For each £100 nominal value 10% standard ordinary of the Chertsey Company holders were given the option of receiving £245 in cash or 183 South-Eastern Gas £1 ordinary, credited as fully paid; for each £100 7% standard ordinary £178 in cash or 133 South-Eastern Gas £1 ordinary; and for each £100 5% standard ordinary £135 in cash or 100 South-Eastern Gas £1 ordinary.

The paid-up capital of the Corporation is now £1,565,928, of which £834,817 is in £1 ordinary and £731,111 in £1 4½% preference.

The combined total of the Chertsey Gas ordinary stock is £35,000.

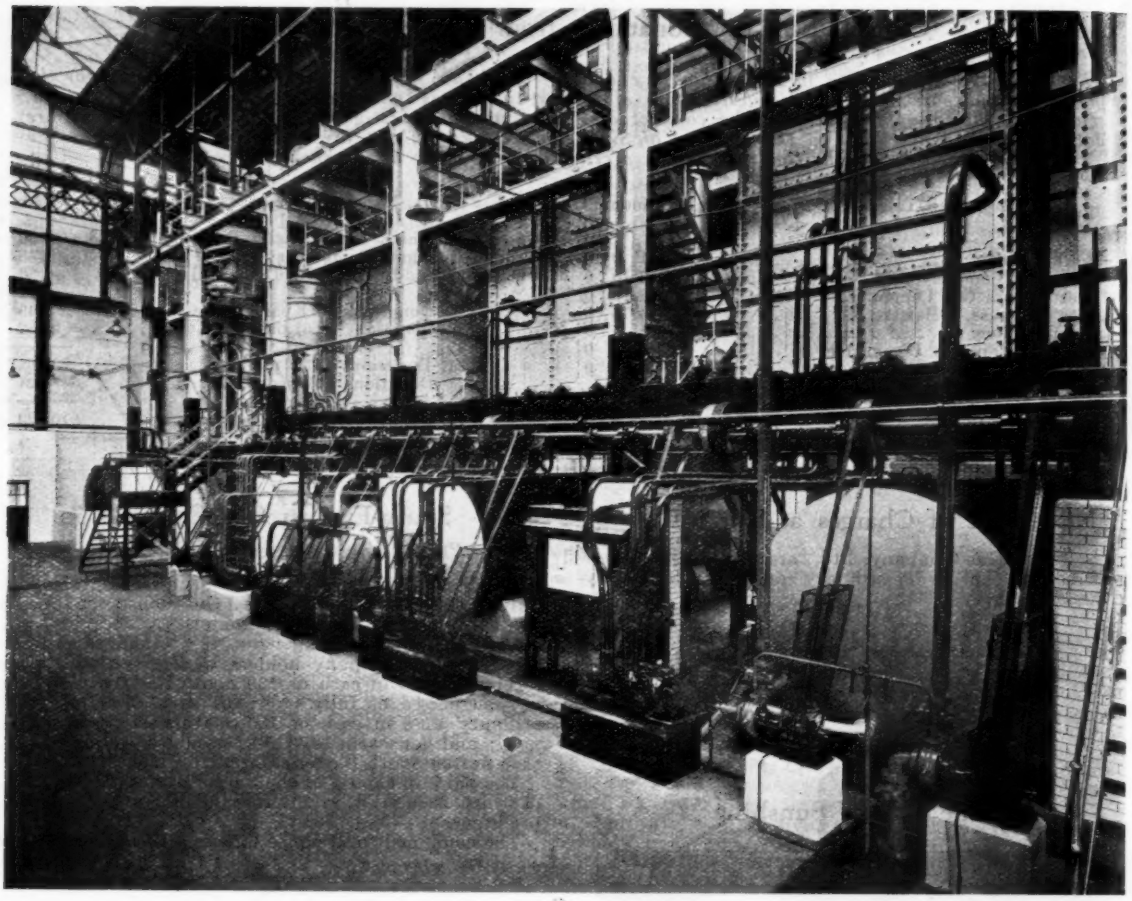
Cookery Demonstrations at Nottingham.

[*Photo by the "Nottingham Journal."*

Cookery demonstrations were held recently at Nottingham, and an interesting innovation was introduced by setting aside a special session for the local Girl Guides' Association. The Commissioner for the Eastern District (Lady Readett-Bayley) very kindly agreed to open the demonstrations under the Chairmanship of Sir Albert Ball. The girls were very enthusiastic about the demonstrations and passed a hearty vote of thanks to Miss Kirkby. Interesting conversations were also carried on between the Guides and a talking "New World" cooker, and this new departure should undoubtedly assist very materially the interest in gas among the younger generation. The photograph shows Lady Readett-Bayley, on whose left is Mr. George Dixon, the Engineer and Manager of the Nottingham Corporation Gas Department, and Mr. Collard.

BENZOLE RECOVERY AT LEEDS

New Plant Inaugurated



THE NEW BENZOLE RECOVERY PLANT AT LEEDS.

A new benzole recovery plant, the total cost of which, including washers and connections, has been over £6,000, was officially inaugurated at the Meadow Lane Gas-Works, Leeds, on May 24, by Alderman R. Tortington, J.P., Chairman of the Gas Committee. Messrs. W. C. Holmes & Co., Ltd., were responsible for the installation, which is capable of dealing with 7 million c.ft. of gas per diem.

The washers are of Messrs. Holmes' patent multifilm brush type. In two of these creosote oil is used for the extraction of benzole, and in the last washer gas oil is used for naphthalene removal. At the top of each washing chamber sprays are provided through which the washing medium is sprayed on to brushes. The brushes are made from the same type of reed material as used in Holmes rotary brush washer, but designed in the form of hurdles and placed vertically and packed together in the washing chambers.

The washer units are provided with centrifugal pumps which circulate the washing medium in corresponding chambers of the washer. The washers are provided with 24-in. inlet and outlet mains with by-passes.

The crude benzole still is of cast iron 5 ft. by 4 ft. diameter and contains 12 stripping trays. The oil heaters are of the vertical multitubular type, mild steel casing 3 ft. 6 in. diameter and 12 ft. long.

To give a high quality crude benzole the vapours pass through a column 21 in. diameter by 9 ft. 6 in. deep, containing special ring filling. Condensers are fitted at the top of this column, consisting of mild steel casing 4 ft. by 3 ft. 3 in. by 9 ft. 3 in. high containing 684 weldless steel tubes 1¼ in. external diameter arranged horizontally; cast-iron headers are fixed, and the tubes are divided into three nests, two for heating the entering cold oil, giving vapour to oil heat exchange. The third section (the last) is cooled by water.

The crude benzole condenser and separator consists of a mild steel cylindrical casing 4 ft. 4 in. diameter by 12 ft. 6 in. high, divided into two compartments, the upper portion forming the condenser and the lower the separator. The oil coolers are of cast iron, the hot oil entering at the bottom and cold oil leaving at the top. Water is distributed by means of trays fitted with V notches.

All the water from the crude benzole condenser and oil coolers is circulated through a water cooler which is provided with induced draught. The pumps are driven from a line shaft which in turn is driven by a Reader high-speed steam engine.

An average distillation test of crude benzole produced is:

1st drop	63° C.	..
	100° C.	68%
	120° C.	86 ,,
	145° C.	97 ,,

The importance of this development to the Gas Industry was stressed by Lieut.-Col. W. M. Carr at the inauguration. From his experience of benzole extraction he could definitely say that it paid to do it. The plant they were opening was a small illustration of the enormous service the Gas Industry was still giving to the country. In fact, the nation could not do without the Gas Industry.

Major C. G. Lyon, Chairman of Yorkshire Tar Distillers, Ltd., also paid a tribute to the enterprise of the Gas Department and its Manager, Mr. C. S. Shapley.

Mr. D. M. HENSHAW (Managing Director of Messrs. W. C. Holmes & Co., Ltd.) said he was glad to have this opportunity of thanking the Leeds Gas Committee and Mr. Shapley on behalf of his firm for having enabled them to carry out this contract under such favourable conditions in regard to the site. It was unique in his experience that such a fine building should be available and that it was possible to lay out the whole plant so as to secure ideal conditions in regard to accessibility or supervision and working space for overhauling. Their thanks were due to Mr. Shapley for his enthusiastic co-operation in bringing the scheme to a successful conclusion, in which all the members of his staff had given of their best. They were reminded that Leeds was one of the first cities to lend their aid when increased output of benzole became so vital to the successful prosecution of the war, and Mr. Shapley had maintained the output of benzole continuously at the New Wortley Works since that time.

A New "Alwyne Meade"*

Book Review by T. Campbell Finlayson, M.Sc., M.I.Chem.E.

It is a great testimonial to the value of a text-book on some subject when the author's name becomes synonymous with the title of his book. For almost twenty years "Alwyne Meade" has been the standard British book on Gas-Works Practice, and for every one who knew the title "Modern Gasworks Practice" there were probably ten who knew and referred to the book as "Alwyne Meade."

It is probably not exaggerating matters to say that this book in its earlier editions has held a unique position as a reference book on Gas Manufacture. Many a student has gained his first knowledge of the practical problems of gas manufacture from its pages. Many an engineer has turned to the book for guidance on matters outside his immediate knowledge.

More than a dozen eventful years have passed since the last edition of "Alwyne Meade" appeared. A new edition of this book will therefore arouse more than usual interest among the many who hold well-thumbed copies of its predecessors.

In his preface the author refers to the revolutionary changes which have taken place in gas manufacture during the past decade. He therefore decided to wait for a time when the Gas Industry had technically reached a state of greater quiescence, in order to commit to permanent form facts and figures which could at least be expected to remain of value for some few years. Although some who endeavour to follow the technical developments taking place in the Gas Industry may not be able to share with the author the atmosphere of quiescence to which he refers, yet it is good that he has decided to give us a cross-section through the state of gas production technique as it exists to-day, and there is no doubt at all that the facts and figures he has collected in this new and enlarged edition will be of great value to the many who will refer to its pages until "Alwyne Meade" Fourth Edition appears.

To cover the vast field of gas manufacture the author has found it necessary to divide his book into two volumes. The first, relating to the design and construction of gas-works carbonization plant and to mechanical handling of materials, was published this week.

In his title the author gives the keynote of his writing. He has set out to write a book on Gas-Works *Practice*. Upon the practical nature of the text the success or otherwise of the book should be judged.

A Mine of Practical Information.

The essence of a practical text-book is that it should be able to supply information of a concrete nature to a person without knowledge on the particular subject. So many text-books fall short in this respect. Not so this one. Mr. Alwyne Meade has given the Gas Industry a veritable mine of compact and practical information on carbonization plant. It is difficult in the space of a few hundred words to convey an impression of the contents of the "New Modern Gas-Works Practice." But to many a reader the book will be judged by whether it supplies an answer to a particular question which is exercising his mind. Therefore it may be of interest to write down, quite at random, half-a-dozen questions and see whether the book can supply the answers.

(1) In the building of a complete gas-works what percentage of the total expenditure is represented by carbonizing plant?

(2) What are the relative amounts of ground space required per unit of gas output on present-day types of carbonizing plant?

(3) How much steam can be expected to be recovered by means of waste-heat boilers on modern carbonizing plants?

(4) How can one determine the capacity of a belt conveyor?

(5) What is the principle of the Askania regulator?

(6) What are the leading types of coke screen available to-day?

It is interesting to find that answers of a definite nature are available to each of these questions.

On p. 30, in dealing with the estimated cost of a works producing 500 million c.ft. per annum, it is shown that the carbonizing plant represents 33% of the total expenditure. Output per unit of ground space is dealt with on p. 128. Waste-heat recovery data for different types of carbonizing plant are collected in a table on p. 217. A formula for working out the capacity of a belt conveyor is given on p. 308. The Askania and other regulators are clearly explained on p. 276 *et seq.* A well-illustrated chapter on coke screening and grading gives an account of some fourteen different screens.

It is suggested that in answers to many a random question, "Alwyne Meade" will pass "with credit."

Survey of the Book.

And now for a brief survey of the book itself. The first chapter deals with the planning and laying out of gas-works. A brief review is given of existing legislature relating to gas supply, and then the various factors which have to be considered in setting-up a new works are dealt with, such as choice of calorific value and capital expenditure. A section is given on general rules for size and capacity of gas-works plant starting from retort house and finishing at the holder. The second chapter deals with the various types of foundations likely to be required in gas-works construction, including mass concrete, rafts, and piles. Consideration is next given to the construction of gas-works buildings, attention being drawn to such matters as modern forms of retort house flooring. The third chapter, which is entitled the "Horizontal Retort Bench," gives a detailed consideration of horizontal retorting practice and also covers such points as producer design—both stepgrate and mechanical—chimney design and regenerator design. Carbonization in continuous vertical retorts is dealt with in the next chapter, the main principles of the leading systems being adequately described and illustrated. Intermittent carbonization in ovens forms the subject of chapter 5. Under this heading are grouped horizontal ovens (very briefly discussed), intermittent vertical retorts, and intermittent vertical chambers. The importance of the last named is one of the "new features" of the book. The Woodall-Duckham, C.O.L., Gibbons, and Jenkins Klönne systems are all described and illustrated. The general principles of the control of retort settings are next explained, with particular regard to fuel economy. Chapters 7 and 8 are newcomers dealing with the dry quenching of coke and waste-heat recovery. Then the subject of refractory materials for gas-works is discussed, including such aspects as standard specification for materials, testing of refractories, and so on. "Retort House Appurtenances" is found to be the title given to an important section of an essentially practical nature dealing with such matters as dip pipes, hydraulic mains, tar and liquor separators, and retort house governing.

Chapter 11 may almost be said to form a book on its own as it extends to over one hundred pages. It deals in a comprehensive manner with the mechanical handling of gas-works materials and covers a wide range of equipment. Wagon tipplers, coal breakers, elevators, belt conveyors, lip-bucket conveyors, coal blending machinery, skip hoists, retort charging machines, and hot coke conveyors are considered. It can easily be imagined that to many engineers this will be the most useful chapter in the book.

This is followed by an informative chapter on coke screening, grading, and cleaning, in which leading types of screens, cutters, and cleaners are discussed in detail. Vol. I. concludes with a section on electrical plant in gas-works.

In his preface the author states that he has endeavoured to cover the vast field embraced by his title as comprehensively as possible so that his book may find some use in the Gas Industry as a practical reference work. There can be no doubt that Mr. Alwyne Meade has achieved what he set out to do, and the Gas Industry owes a debt of gratitude to him. Many a knotty problem and many a doubt will find quicker solution by the satisfactory feeling that reference can be made to "Alwyne Meade—1934."

* "The New Modern Gas-Works Practice," by Alwyne Meade. Vol. I. Design and Construction of Gas-Works Carbonization Plant, Mechanical Handling of Materials. Published by Eyre & Spottiswoode, London, 1934. Price, 50s. net.

Degree-Days

By A. F. Dufton, M.A., D.I.C., of the Building Research Station, Watford.

[Reprinted by permission from the April issue of the Journal of the Institution of Heating and Ventilating Engineers.]

Although it is well known that more fuel is required to heat a house in the north of our island than in the south, few people have an accurate idea of how fuel consumption varies with locality. The data upon which such an idea can be based, however, are available in the form of monthly normals of temperature (max., min., and mean) in Section I. of "The Book of Normals," published by the Meteorological Office (H.M.S.O., 2s. net).

American engineers have taken considerable interest in fuel consumption and have found the "degree-day" to be a very useful unit of reference. The term degree-day originated in the Gas Industry and was standardized by the American Gas Association as a unit which is the difference between 65° F. and the daily mean temperature when the latter is below 65° F. Unless otherwise specified, the number of degree-days for a locality is always taken to mean the annual total.

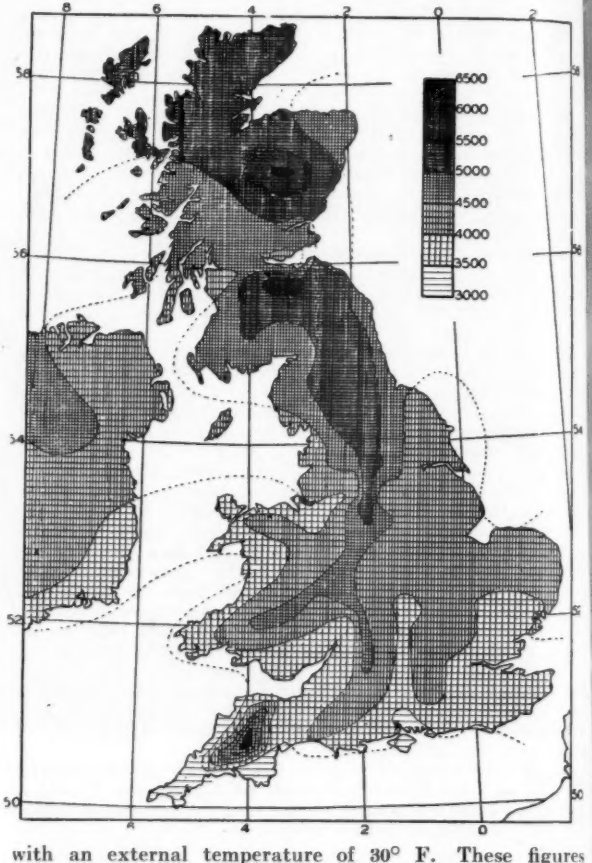
In America, the base of 65° F. was chosen (for inside temperatures of 70° F.) because it was demonstrated that 65° F. is the maximum temperature at which fuel is burned to supply heat to a residence and because the fuel consumed varied almost directly with the difference between 65° F. and the outside temperature. In our own country, where an inside temperature of 65° F. is generally preferred to one of 70° F., it would seem desirable to adopt a temperature of 60° F. as the base for a British degree-day.

Reference to "The Book of Normals" indicates that, at Greenwich, on this basis, heating is normally unnecessary from about the middle of June to the end of the first week in September; and this seems to be reasonable.

The accompanying map, which shows British degree-days for Great Britain and Northern Ireland, is contoured from the information given in "The Book of Normals."

In the interests of accuracy, it must be pointed out that only two of the stations for which data are given are more than 1,000 ft. above mean sea level—Braemar (1,120 ft.) and Princetown (1,359 ft.)—and it will be seen that, while Dartmoor appears as a cold spot, the contouring does not truly show the coldness of Snowdon or of Ben Nevis. The effect of altitude, which amounts to an increase of roughly one degree-day per foot, is complicated by the influence of the configuration of the land and of the distance from the sea. It has not been thought worth while to attempt to amend the contouring by adopting such a correction, particularly as the areas remote from meteorological stations are all sparsely populated.

It is of interest that Mr. A. H. Barker, in his comprehensive paper on "The Relative Fuel Economy of Electricity, Gas, Oil, and Solid Fuel as Heating Agents," calculated the total fuel used throughout a winter as equivalent to 20 weeks at full power, full power being that required to maintain an internal temperature of 60° F.



with an external temperature of 30° F. These figures imply a total of 4,200 degree-days and the map confirms that this is a good average figure for England.

IN CONTINENTAL COUNTRIES - - -

Abstract Translations from the Technical Press of France and Germany.

COAL BRIQUETTING WITHOUT A BINDER.

J. Holik, in *Glückauf*, 1934, **70**, 385-393 (April 28), describes the Apfelbeck briquetting press used for the briquetting of a bituminous coal in the Rtanj Collieries in Jugo-Slavia. The briquetting properties of coal are first discussed and a triangular C,H,O diagram showing the range of coals which can be briquetted without a binder is given. The process employed at Rtanj does not require the use of a binder. The coal employed has the composition: Moisture 0·6%, volatile matter 23·2%, ash 13·8%, and is strongly caking. It is a washed product and is dried in a thermal drier with combustion gases.

The press contains two vertical rings, one recessed into the other so that a ring-shaped cavity of rectangular cross-section is left. Two rollers keep the rings together at the bottom while they are kept slightly apart at the top by means of distance pieces. The rings are rotated by means of rollers driven by a motor. Inside the rings is a heavy roller with 14 peripheral teeth, the distance between the teeth corresponding to the length of the briquettes. This roller is forced down by a spring device acting on its axle. The dried 3 mm-O coal at a temperature of 80°-100° C. is fed into the press and becomes compressed into the cavity by means of the toothed roller, which rotates by friction. As the rings travel round, the briquettes move towards the top and, on reaching the widened part of the cavity, become loose and are broken at the tooth indentations by means of a ratchet. The briquettes are very strong and weather well.

The pressing time is 1 second. The output of the press is 5 tons per hour, and a daily tonnage of 110-130 is regularly realized. The pressure developed is 1,500-1,600 atmospheres and the power consumption is 10 HPH per ton of briquettes.

Only after a throughput of 45,000 tons did it become necessary to change the smaller of the two rings. The larger one was then re-ground and again used. The remaining parts suffer no appreciable wear.

A NEW HEAVY-LIQUID COAL WASHING PROCESS.

K. Gröppel, in *Glückauf*, 1934, **70**, 429-435 (May 12), describes the coal washing process introduced by de Vooys at the Sophia-Jacoba Colliery. The coal ($3\frac{1}{8}$ in.-$\frac{3}{8}$ in.) is

washed by means of a heavy liquid consisting of an aqueous suspension of clay and barytes. The latter is used in the form of the crude mineral (purity 96%) and is obtained at a cost of 31s. per ton [Marks converted at par of exchange] in the form of a powder of such fineness that 98% passes a sieve of $\frac{1}{500}$ in. square aperture. Liquids having specific gravities as high as 1·6 are readily obtainable. The mixture in actual use has a specific gravity of 1·47. Diluted liquid obtained in the process is re-thickened to this specific gravity and the thickened liquid remains in stable suspension for 24 hours.

The coal treated must be freed from dust and fusain either by efficient screening or spraying. It is fed into a wash box into which the washing liquid is admitted peripherally some distance below the liquid level. A drag conveyor removes the float coal and a bucket elevator the refuse. The clean coal and refuse are sprayed with water and the resulting dilute liquid is freed from coarse particles by means of a bronze wire conveyor sieve of $\frac{1}{200}$ in aperture. This allows the clay and barytes to pass through with the water. The dilute liquid passes to a thickener, the overflow from which is again used as a spray medium, while the thickened product and the overflow from the wash box pass to a sump from which the mixture is pumped back into the wash box to serve anew as washing medium. The refuse may be re-washed in a jig-washer, if desired, to recover boiler fuel. The clean coal is again thoroughly sprayed to render its appearance bright and is screened into nuts of various sizes.

Though the viscosity of the clay-barytes suspension compares favourably with that of other heavy wash liquids, its viscosity is still further reduced since it is employed at a temperature of 35° C., the necessary heat being supplied through a steam-heated jacket surrounding the mixing sump.

The following table shows the results in comparison with those obtained with a jig-washer.

The results obtained with the heavy liquid process are very close to the theoretical figures deduced from the washability curves, and the yield of clean product is much greater than is obtained in a jig-washer. The average increase in yield is 4%. The capacity of the plant can be varied between 1 and 230 tons per hour, the same efficiency being maintained over the whole range.

Process.	Ash in Feed.	Product.	Yield.	Ash Content of Products.			Floats or Sinks in Products.	
				Theoretical.	Actual.	Difference.	%	Ash.
	%		%	%	%	%		%
Jig-washer	20·83	Clean coal	60·0	2·75	4·05	1·30	2·64	25·00
		Shale	40·0	47·90	46·00	1·90	11·78	5·69
Heavy liquid	20·13	Clean coal	68·5	3·27	3·33	0·06	0·90	15·93
		Shale	31·5	56·80	56·66	0·14	0·80	10·52

The following data relate to a throughput of 150 tons of coal per hour [Marks at par of exchange].

	Cost per Ton of Coal. d.
Labour, six men per shift at 8s. per shift	0·48
Power, 115 KW.H. at $\frac{3}{4}$d. (includes coal handling, preliminary and final screening, pumping, thickening, and mixing)	0·29
Water (66 gallons per ton*), at 4$\frac{1}{2}$d. per 1,000 gallons	0·28
Maintenance and lubrication	0·72
Barytes make-up (1 ton per 1,000 tons of coal), at 31s. per ton	0·37
Steam (4 tons per 1,000 tons of coal) at 2s. 6d. per ton	0·12
Total	2·26

*85% used for the final spraying of the clean coal.

The cost is slightly less than that of jig-washing and decidedly less than that of the Lessing process. In comparison with a jig-washer, the extra costs for steam and barytes are rather more than counterbalanced by the savings in power, maintenance, and lubrication.

Reconstructed Showrooms at Twickenham

Gas Light and Coke Company's Fine Premises

The Gas Light and Coke Company have struck a new note in exterior design in their new showrooms opened on May 24 at Twickenham. The fifty-fifth showroom in their area of supply, this latest example has been conceived on thoroughly modernistic lines, with its black marble base, stainless steel fluted columns, wide windows, surmounted by bright blue tiles, on which the Company's name has been executed in stainless steel tubular lettering. Situated on a bend of York Street, one of Twickenham's principal thoroughfares, the showroom makes a very attractive and imposing building.

Modern as is the style of the exterior, the interior of the showroom is no less up-to-date in its layout, furnishing, and equipment. It is divided into five main sections—four of them in front, each having a showroom window on the street—and the fifth at the back. Entering by the main door, access is gained to the first section, which is devoted to a series of gas fires in coloured settings, a wide range of attractive lighting fittings, together with the "gadget table" on which are set out examples of all the smaller portable appliances which can be "plugged-in" to gas.

Water Heating Display.

The next section contains a comprehensive display of gas water heaters of all types. At the back is a recess in which are fitted the instantaneous heaters, arranged to discharge their hot water into a common stainless steel trough. The larger storage heaters and boilers arranged close by deliver into the same trough by means of separate taps. Also in this section are examples of gas wash-boilers and a gas-heated clothes drying cabinet, thermostatically controlled.

A pleasing display of modern gas cookers in attractive enamelled finishes is found in the third section, which also contains examples of small radiators for halls and passages, together with a coke fire in stainless steel, and fitted with gas ignition device, for burning the Company's specially prepared and graded smokeless solid fuel—which is marketed under the name of "Cleanglow."

In the fourth section is the cashiers' counter, so arranged that customers have to pass right through the main sections of the showroom before reaching the counter, thus giving them the opportunity of seeing all the appliances. There are additional gas fires, of the built-in variety, in this section. The fifth section lies behind, and is devoted to a further display of cookers of various kinds and in various finishes, all fitted with lighting attachments, either of the "gas match" or the pilot type. Gas-operated refrigerators are also exhibited in this section. The lighting of the interior is pleasing and effective, and is carried out by means of pendant fittings, switch controlled.

The building has been erected on the site of the original gas showrooms in Twickenham, but has been considerably enlarged.

The Opening Ceremony.

The new premises were declared open by His Worship the Mayor of Twickenham (Alderman G. A. Farrer, J.P.) in the presence of a large gathering of members of the Borough Council and prominent local residents, prior to which those present were entertained at tea at the invitation of the Gas Light and Coke Company in the Town Hall, York House, Twickenham, which is a historic mansion not far from the showrooms.

Sir David Milne-Watson presided, and was supported, in addition to the Mayor and Mayoress, by Mr. R. W. Foot (General Manager), Mr. Thomas Hardie (Chief Engineer), Mr. Stephen Lacey (Controller of Gas Sales), and other senior officers of the Company. In thanking the Mayor for coming to perform the opening ceremony, Sir David recalled that it was exactly eight years ago that Twickenham was granted her Charter—just at the time when the Gas Light and Coke Company took over the district; so in this respect there was a link between them.

The Mayor, in reply, remarked that the Corporation of Twickenham were very glad to meet the Company there that day and celebrate what he supposed was a milestone in the progress of the Company—at least in this particular district. He expressed appreciation of the great assistance the Company had rendered in connection with the town's carnival day, whereby the ancient and historical building in which they were seated would be flood-lighted by gas, so that they would be able to show it in its true glory.

The Mayor then proceeded to the new showrooms, where Sir David presented him with a silver key with which he formally opened the main door.

Southern Association of Gas Engineers and Managers

Visit to Watson House and Fulham Stove Shops

Members of the Southern Association of Gas Engineers and Managers honoured their President (Mr. Stephen Lacey, Sales Controller of the Gas Light and Coke Company) by accepting in large numbers an invitation to be the guests of his Company on Friday, May 25. Over 100 members were present.

A full and interesting day's programme was arranged by the kindness of the Governor and Directors of the Gas Light and Coke Company, comprising a visit to Watson House in the morning and to the Fulham Stove Repair Shops after lunch. Members assembled at the Chief Office of the Company in Horseferry Road, Westminster, at 10 a.m., and were conveyed by motor coach to Watson House, where they viewed the Utilization Research Laboratories, Testing and Training Shops, and the Industrial Centre. Space does not permit of our describing here again the many ramifications of Watson House, but an interesting outline of the work carried out was given in the latter half of Mr. Lacey's Presidential Address to the Southern Association two months ago (see "JOURNAL" for March 28, p. 812). As he said on that occasion, Watson House can only be seen in proper perspective when it is realized that the Gas Sales Department of the Gas Light and Coke Company is responsible for approximately one-sixth of the gas sales in Great Britain.

Particular interest was taken in a display of appliances, fittings, and tools entirely evolved and developed by the staff at Watson House. These included such apparatus as the G.L.C. single-point water heater, the G.L.C. gas cooker and gas iron, together with examples of ventiles and other types of flue equipment, numerous forms of governors, cut-off valves, inside and outside lamps, meter bars, panel heaters, &c.

LUNCHEON.

After a comprehensive tour of Watson House, the members returned to Horseferry Road, where they were entertained at luncheon, Sir DAVID MILNE-WATSON, LL.D., D.L., Governor of the Company presiding, supported at the top table by Mr. Henry Woodall (Deputy-Governor), Senior Officers of the Gas Light and Coke Company, and Past-Presidents and Officers of the Association.

A cordial welcome was extended to the Association by Sir DAVID, who remarked that he was not altogether a stranger to them, as they had done him the great honour a few years ago of electing him an Hon. Member—an honour which he greatly appreciated. It was a great pleasure to him to be there that day, as their President was one of the most esteemed officers of the Gas Light and Coke Company; he came of a family which had left its mark on the history of the Gas Industry and of the Gas Light and Coke Company. They had that day visited Watson House and were about to inspect the Fulham Stove Works, and he hoped they would find much to interest them. The Company wished to show the members what they were doing on the technical side of their selling activities; for, to his mind, selling was the most important side of the Industry to-day, and at Watson House and Harwood Terrace they would see what the Gas Light and Coke Company were doing to make the technique behind the selling as efficient as possible.

IMPORTANCE OF ENAMEL.

He had spoken a few days previously at the annual meeting of the National Gas Council on the subject of enamel. He did so quite seriously because he believed that the application of enamel was one of the most serious questions in the Gas Industry. Enamel was going to sweep the board, and if the Industry did not go on with it they would be left behind. The "other side" were pushing enamelled cookers, and the Gas Industry must scrap their ugly black cookers—for if they did not do it for themselves the electricians would do it for them. If they put their house in order in this respect and kept abreast of the times there would be nothing to fear in the future. This was one of the reasons why he welcomed the Association there that day; he looked to them to spread these matters and see that the Gas Industry was kept thoroughly up-to-date.

Mr. STEPHEN LACEY first thanked the Governor for his kind references to himself, and then, as President of the Association, for the most cordial welcome he had extended to them. Mr. Lacey expressed his pleasure in seeing such a representative gathering of members. The visit that day was of special interest because it exemplified the technical background of the Gas Light and Coke Company.

Mr. E. L. NICHOLAS (Vice-President of the Association) also expressed the thanks of the Association to the Gas Light and Coke Company for their kindness and hospitality. They had thoroughly enjoyed their visit to Watson House and anticipated quite as pleasant and instructive time during the afternoon. He also thanked the guides who had shown them round. He asked them to drink a toast to the Gas Light and Coke Company, with which he coupled the names of the Governor and Deputy-Governor.

The toast was enthusiastically honoured, and Sir DAVID MILNE-WATSON, in acknowledgment on behalf of Mr. Woodall and himself, remarked that it was always a pleasure to see round their board members of the Gas Industry and none more than the Southern Association.

Luncheon over, the members set out by motor coach for Fulham, where they inspected the Stove Works—one of three in the Company's district. The area of the shops, stores, and other buildings amounts to nearly 90,000 sq. ft., and the number of men and boys at present employed at these works is 466. Some idea of the capacity of the works may be gained from the fact that during the year 1933 more than 95,000 appliances were dealt with.

At the conclusion of the inspection tea was served, and the visit terminated with further expressions of thanks to the President and his Company for their hospitality.

Cookery Demonstrations at Bletchley.

A series of gas cookery demonstrations and an exhibition of gas appliances were held in the Bletchley High Street Schools recently.

The exhibition was opened by the President of the Bletchley and District Chamber of Commerce, Sir Everard P. D. Pauncefoot Duncombe. Mr. Graham Wilkin, a Director of the Company, was in the chair, supported by Sir Everard and Lady Duncombe and Mr. Jasper Cook, the Engineer and General Manager of the Company's Fenny Stratford Station. Both afternoon and evening during the four days of the exhibition, Mrs. Stella Crump, of Radiation, Ltd., gave cookery demonstrations. Tea was provided by the Company.

There were very good attendances at all the lectures, and many expressed appreciation of the delightful way Mrs. Stella Crump dealt with the many cookery questions which were asked. Miss C. Haslam also demonstrated washing machines.

French Gas Congress.

The Fifty-Seventh Congress of the Association de l'Industrie du Gaz en France is to be held in the Maison du Gaz, 21, Rue Blanche, Paris, from June 6 to 8 under the Presidency of M. Prosper de Lachomette, of Lyons. The annual banquet of the Association takes place on the Wednesday evening in the Salle Hoche, Paris. On the following afternoon the Nanterre Works of the Société Lyonnaise des Eaux et de l'Eclairage is to be visited.

Included in the communications offered is one by Mr. Walter T. Dunn, M.I.Mech.E., former Secretary to the Institution of Gas Engineers, on "Observations on Features of Modern Plant and Apparatus used by Gas Undertakings."

On Saturday, June 9, the members leave Paris by train or autocar for Tours, visiting on the following morning the Tours Works of the Compagnie Generale du Gaz pour la France et l'Etrangers, after which the Company will entertain the visitors at luncheon in the Grand Hotel, Tours. Subsequently the Chateau de Chenonceaux will be visited.

THE INSTITUTION MEETING

JUNE 5—8, 1934

The business sessions will be held in the Great Hall of the Institution of Civil Engineers, and through the courtesy of that Institution we are able to publish on this page a photograph of their imposing Headquarters in Great George Street, S.W. 1.

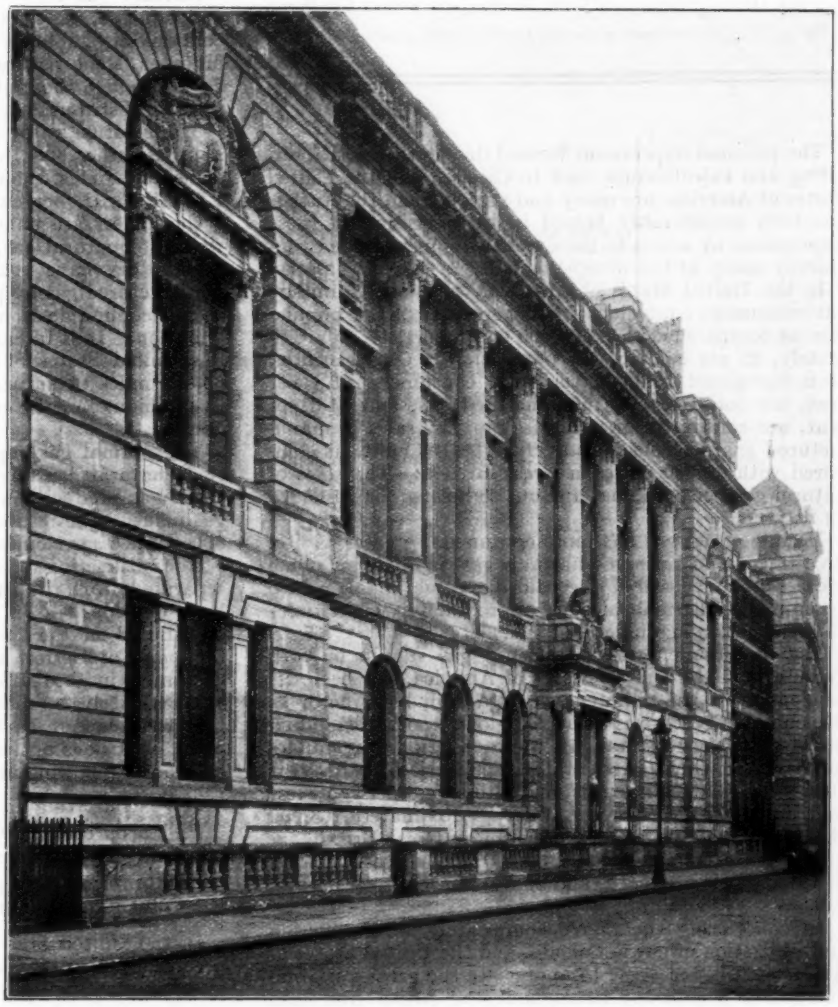


Photo. by Bedford Lemere

In the following pages is the bulk of the papers to be presented at the 71st Annual General Meeting of the Institution of Gas Engineers, to be held in London next week under the Presidency of Mr. Frank P. Tarratt, M.Inst.C.E., of Newcastle. It is felt that readers will appreciate as a handy reference this compact record of the contributions to be discussed at the Meeting.

Impressions of the Gas Industry in Canada and the United States of America

1—Gas Production

By Colonel W. MONCRIEFF CARR, T.D., M Inst.Gas E.,

Engineer, General Manager and Clerk, Stretford and District Gas Board.

The personal impressions formed during the most interesting and kaleidoscopic visit to Canada, and the United States of America, are many and various, and the Author has been considerably helped in the focussing of these impressions by access to the excellent reports made available by many of the members of the Institution's party.

In the United States of America, there are 16 million gas consumers equivalent to 13 per cent. of the population as compared with 9,800,000 consumers, or, approximately, 22 per cent. of the population in Great Britain. It is significant that, of the total consumers, 65·4 per cent. are consumers of manufactured gas, and 34·6 per cent. are consumers of natural gas. The sales of manufactured gas per consumer average 38,493 cu.ft. as compared with 29,360 cu.ft. in Great Britain. The sales of natural gas per consumer amount to no less than 165,979 cu.ft.

Manufactured gas has more consumers, greater capital investment and revenue; natural gas is sold in much greater volume, and if the calorific value is taken into account, the thermal sales are approximately eight times as great as for manufactured gas.

The development of the natural gas supply in both Canada, and the United States of America, has been dependent upon the maintenance of a high load factor as the commodity cost is relatively low; notwithstanding the large sales of natural gas, the production of manufactured gas in the United States of America in the year 1932 was 358,876 Mn. cu.ft., and although 8 per cent. less than in the preceding year, was, approximately, 63,000 Mn. cu.ft. more than the production in Great Britain.

In Canada, approximately 30,000 Mn. cu.ft. of manufactured gas is produced, and 26,000 Mn. cu.ft. of natural gas.

In considering the above comparisons of production and utilization of gas in Canada, and the United States of America, it is necessary to appreciate the great variation in climatic conditions throughout the North American continent, a great part of which is subject to more severe winter conditions than is Great Britain, and, therefore, the comparison of fuel consumptions on a *per capita* basis may be erroneous.

It would appear that, unlike manufactured gas in this country, the development of which is hampered by antiquated restrictive legislation, the natural gas supplies in the United States of America are being over-developed for lack of some restrictive legislation.

The natural gas supply companies have to be prepared to deliver gas in volumes sufficient for the maximum demand, and this demand has to be met from sources of supply which diminish as the gas is taken. In some instances, gas wells fail without warning, and this is a further reason why development must, in any case, be very much in advance of the demand.

In developing natural gas supplies, it appears that very little consideration has been given either to the economical spacing of the wells or to the demand for gas, and, in some instances, as many as 30 to 40 wells have been drilled into a particular reservoir, because of the different interests represented in the land ownership, when 3 or 4 wells would be sufficient to provide a flow to meet the requirements, and ultimately to drain the reservoir.

In Canada, the principal developed natural gas fields lie in the southern part of the province of Ontario in a belt extending from 30 to 40 miles wide and stretching some 250 miles along the north shore of Lake Erie from Niagara River to the Detroit River.

Natural gas consists principally of methane, ethane, and propane. In the Ontario Natural Gas Fields, the gas contains no sulphur. In the United States of America, however, some natural gas has an extensive content of H_2S, although the bulk of the gas produced is sufficiently pure for distribution direct from the wells.

The calorific value of the gas in the Ontario Field is approximately 800 B.Th.U. per cu.ft. In some of the American Fields, the normal calorific value is as much as 1,200 B.Th.U. per cu.ft.

Gasholders are unnecessary where the supply consists wholly of natural gas, and in Ontario wells which have become dry have been used for the purpose of storing manufactured gas by pumping gas back into them.

This communication does not purport to deal with distribution. It is interesting, however, to observe that in the United States of America there are approximately 65,000 miles of natural gas pipe lines, and the sales to five million domestic consumers total more than 1,900,000 Mn. cu.ft.

The normal gas supply of Chicago consists of 45 per cent. natural gas mixed with 55 per cent. of manufactured gas produced in coke ovens and carburetted water gas plant. The resultant mixture has a calorific value of 800 B.Th.U. per cu.ft.

The utilization of propane, which, with butane, is separated from the casing head gas in the oilfields, has been developed as a gas supply for domestic purposes distributed in the form of bottled gas. The Philgas Company of Detroit supply bottled gas to some 30,000 customers in 16 districts, each of which has a radius of, approximately, 30 miles.

Butane cannot be used in the same manner as propane, as it does not so readily volatilize; it is, however, put to the following uses:—

(1) Carburetting air in butane air plants.
(2) Carburetting blue water gas or generally for enriching poor gases.
(3) Re-forming by pyrolysis to produce a gas suitable for general distribution.

In the United States of America, there appears to be a considerable difference of opinion between natural gas and manufactured gas interests as to how far natural gas supplies should be extended, and this is understandable in view of the over-development of natural gas supplies which are, in consequence, in many instances, excessively capitalized. Manufactured gas plants have, in some instances, been closed down in attempts to make the natural gas pipe lines remunerative.

The impression gained is, that the available sources of natural gas will be balanced with gas production from coke ovens coupled with carburetted water gas having regard to locality, cost of coal particularly as affected by transport, and the demand for coke for the steel industry and domestic heating.

MANUFACTURED GAS.

(1) General Considerations.

The development of gas manufacture in the United States of America, as has been indicated, is greatly influenced by the rapid growth of natural gas; for example, the greater part of the supply of manufactured gas is

from coke ovens, which are primarily operated for the production of coke fuel for manufacturing and domestic purposes, and the supply of town gas often consists of the coke oven gas available together with natural gas. In addition, carburetted water gas and oil gas are extensively manufactured both for admixture with natural gas and for direct supply, and gas plants have been developed as standby for natural gas transmission lines.

The supply of manufactured gas is considered in Canada and the United States of America as almost a separate industry. At the American Gas Association Convention separate sessions are devoted to manufactured gas and natural gas, and statistics relative to the manufactured gas industry are published separately by the American Gas Association.

Table I. from Statistical Bulletin No. 11 of the American Gas Association shews the gas produced and purchased by the manufactured gas industry in the United States for distribution to consumers in the years 1929-1932.

The figures for 1932 shew that the manufactured gas industry in the United States of America, in common with other industries, was affected by the general depression which characterized the year 1932. The Statistical Report of the American Gas Association shews, however, that by comparison with other primary fuel industries of the nation, which are more or less directly competitive in nature, the manufactured gas industry was the least affected, a fact which demonstrates its inherent soundness and stability.

The data on coke oven gas produced relates only to by-product coke ovens which are owned and operated by gas utilities, and there were 21 such plants operated by 18 utilities at the close of 1932, when there were 35 coke oven plants supplying coke oven gas for distribution by gas undertakings, and of these, 20 were connected with the iron and steel industry, while 15 were operated by merchant coke companies.

Table I. also indicates that, whilst the coke oven gas produced by utilities themselves shewed an increase in the four-year period, there was a declining trend in the quantity of water gas produced.

Particulars of the total fuel consumed in the manufacture of gas in the years 1929-1932 are shewn in Table II. extracted from Statistical Bulletin No. 11 of the American Gas Association.

Of the total solid fuels used in 1932, amounting to 11,133,000 short tons, 2,105,000 short tons were used in the production of water gas, which was 19 per cent. below the quantity used in the preceding year, although from

TABLE I.—*Gas Produced and Purchased by the Manufactured Gas Industry in the United States for Distribution to Consumers*, 1929-1932.

Unit: MCF (thousand cu.ft.).

—	1932.	1931.	1930.	1929.	Per Cent. Change 1932 31.
1	2	3	4	5	6
Gas produced—					
Water gas	172,023,000	193,403,000	208,502,000	216,566,000	− 11·1
Coke oven gas	49,267,000	56,266,000	50,839,000	48,814,000	− 12·4
Retort coal gas	32,197,000	38,686,000	40,870,000	41,886,000	− 16·8
Oil gas	6,946,000	7,919,000	8,485,000	8,486,000	− 12·3
Reformed oil refinery gas	4,705,000	4,478,000	2,205,000	616,000	+ 5·1
Butane-air gas	518,000	517,000	89,000	10,000	+ 0·3
Total gas produced	265,657,000	301,269,000	310,990,000	316,408,000	− 11·8
Gas purchased—					
Coke oven gas	92,424,000	109,456,000	118,464,000	114,944,000	− 15·6
Oil refinery gas*	1,743,000	1,473,000	2,009,000	2,176,000	+ 18·3
Natural gas	30,468,000	6,931,000	2,299,000	1,578,000	..
Total gas purchased	124,635,000	117,860,000	122,772,000	118,698,000	+ 5·7
Total gas produced and purchased	390,292,000	419,129,000	433,762,000	435,106,000	− 6·9

* Does not include quantity used in production of reformed oil refinery gas.

Companies formerly distributing manufactured gas, but which were distributing natural gas at the beginning of 1932, have been excluded from the above tabulation for all four years. The data shown above for 1929 and 1930 are, therefore, not comparable with data on the manufactured gas industry previously issued for those years.

TABLE II.—*Comparative Total Quantities of Fuel Consumed by Manufactured Gas Industry in the United States in the Manufacture of Gas*, 1929-1932.

Units: Coal and Coke—Tons of 2,000 Lbs.; Oil—Gallons.

—	1932.	1931.	1930.	1929.	Per Cent. Change. 1932-31.
1	2	3	4	5	6
Anthracite coal	115,000	141,000	206,000	267,000	− 18·4
Bituminous coal	8,103,000	9,544,000	9,525,000	9,549,000	− 15·1
Coke purchased	809,000	937,000	1,162,000	1,270,000	− 13·7
Coke made in plant	1,556 000	2,019,000	2,158,000	2,195,000	− 22·9
Coke breeze	550,000	564,000	481,000	477,000	− 2·5
Total coke and coke breeze	2,915,000	3,520,000	3,801,000	3,942,000	− 17·2
Total solid fuels	11,133,000	13,205,000	13,532,000	13,758,000	− 15·7
Total oil	603,070,000	680,622,000	733,295,000	728,415,000	− 11·4

Companies formerly distributing manufactured gas but which were distributing natural gas at the beginning of 1932 have been excluded from the above tabulation for all four years. The data shown above for 1929 and 1930 are therefore not comparable with data on the manufactured gas industry previously issued for those years.

The figures in this table do not include fuels used in the production of coke oven gas which is purchased by gas companies from coke and steel companies for public distribution.

In considering Table I., it should be observed that there is a greater variation in the calorific value of gas as supplied in the U.S.A. than exists in this country; for example, prior to the completion of the natural gas pipe line from Texas to Chicago, the gas supplied was a mixture of coke oven and carburetted water gas with a calorific value of 530 B.Th.U. per cu.ft.; with the admixture of natural gas, having a calorific value of, approximately, 1,030 B.Th.U. the town supply has been increased to 800 B.Th.U.

Table I. it will be observed that the reduction in the quantity of water gas produced was only 11 per cent. This is stated to be mainly the result of the greatly increased consumption of heavy oils for water gas enrichment, the use of which necessitates relatively less generator fuel, and larger quantities of enriching oil per 1,000 cu.ft. of gas produced.

(2) Carbonization.

The position as to carbonization in Canada varies from that in America, and whilst there have been large discoveries of natural gas in Alberta, the natural gas fields in Ontario are nearing depletion, and in the absence of new discoveries, it appears that Western Canada will have to rely mainly upon carbonization, not only for the production of gas but for the production of coke for domestic heating requirements. Canada has relied mainly on Pennsylvania for supplies of bituminous coal for carbonization, and the balance of her fuel requirements has been provided in imported American and British anthracite.

The Government are anxious to develop the Dominion's own coalfields, which are situated in Alberta, British Columbia, New Brunswick, and Nova Scotia.

The cost of freightage from the coalfields to Ontario and Central Canada is such as to make competition with American coal very difficult, and to overcome this, a subvention is paid by the Government in respect of freight charges. Under this subvention, Alberta coal has been successfully carbonized in the coke ovens at Winnipeg during the past year, and Mr. Hugh McNair, in his Presidential Address at the Annual Convention of the Canadian Gas Association, expressed his satisfaction with the results, the quality of the coke being satisfactory, although on account of lower volatile content, the yield of gas was lower than when carbonizing Pennsylvanian coal.

The investigations conducted by the Fuel Research Laboratories of the Canadian Department of Mines in the carbonization of Canadian coals, both alone and with American coals which have produced satisfactory results, were also reported upon at the Annual Convention. It would appear that the tendency will be towards an increased production of coke from Canadian coal with a lessened importation of anthracite from America.

In view of the desirability of maximum coke production, the tendency in the larger Undertakings, as in the United States of America, is towards carbonization in coke ovens. In both countries it is common for the coke ovens to be under separate ownership, and supply gas in bulk to the gas undertaking.

At the Montreal Works, there was a large installation of continuous vertical retorts, which was not in operation on account of the necessity of the maximum production of hard coke for central heating stoves.

The manufacture of sulphate of ammonia, being uneconomic on account of price, the concentrated ammonia liquor is used for the removal of the bulk of sulphuretted hydrogen in the coal gas, and the resulting ammonium sulphide is disposed of by spraying it into the hot producer gas stream in which it is carried forward to the ovens where the ammonia and hydrogen sulphide are volatilized and burnt with the producer gas. It was stated that, with this process, it is possible to reduce the sulphuretted hydrogen content in the coal gas entering the final purification boxes to from 90 to 120 grains per 100 cu.ft.

The carbonizing plant at the works of the Toronto Gas Consumers' Company, visited by the delegation, conforms generally to normal practice in this country, and consists of 13 beds of continuous vertical retorts with a capacity of 7 Mn. cu.ft. of gas per day, and yielding 73 therms per short ton (2,000 lbs.) with Pennsylvanian coal.

This plant is equipped with water sprays in the discharge mouthpieces to keep down dust, also air blowers with flexible tube connections to the coke car to keep dust away from the operator. The other carbonizing plant consists of 20 beds of horizontal retorts in the rather unusual arrangement of 11 beds per retort, 4 retorts high on the outside, and 3 retorts in the centre. The charging and discharging of this plant was by compressed air.

In Chicago the carbonizing plant of the Peoples Gas Light and Coke Company consists of a battery of 105 Becker ovens, 12½ tons capacity, to carbonize 1,300 tons per day.

The ovens, which are of usual design, are designed for alternative heating by coal gas or producer gas. There are 10 Kerpeley type producers equipped with annular and waste heat boilers which are self-supporting in steam.

Other large coke ovens inspected were the plants of the Davison Coke and Iron Company, Pittsburg, which consists of an installation of 35 Becker type ovens, 17 tons capacity, which carbonize 1,800 tons of coal per day, and supplies gas to the Equitable Gas Company of Pittsburg, and two batteries of coke ovens at the Greenpoint works of the Brooklyn Union Gas Company, producing 22 Mn. cu.ft. of gas per day. The ovens at the Everett Gas Works of the Boston Consolidated Gas Company were also inspected.

Continuous vertical retorts are in operation in many of the medium sized and smaller works, and an interesting development is the production of oil gas in some of the retorts to enrich the coal gas to permit of a greater degree of steaming. In the retorts set aside for oil gas production, gas oil is sprayed in the top of the retort by means of water cooled oil sprays introduced into the retort through the poking hole, and extended approximately 6 ft. from the top casing.

In one installation consisting of 5 beds of 8 Glover-West retorts, 4 in a row, the setting aside of one retort for oil gas production, has enabled sufficient oil to be distilled to increase the calorific power of the gas produced on the bench from 495 to 515 B.Th.U. The actual oil used in the process is stated to be equivalent to 0·325 gallon per 1,000 cu.ft. of gas made.

A considerable amount of work is being done with a view to improving the quality of coke, and to avoid degradation in handling. At Toronto the coke was sprayed on its passage from the retorts to the coke hoppers with a solution of calcium chloride in order to prevent the evaporation of the moisture at normal temperatures, and prevent dust. Calcium chloride treatment is becoming fairly common in the United States of America, and other dust arresting solutions are being tried out.

In the Gas Production Committee's Report of the American Gas Association presented at the Chicago Convention by the Chairman of the Coke Sub-Committee, Mr. R. E. Kruger, some interesting results are given on the results of carbonizing coal with a mixture of a small quantity of coke breeze. The report shews that the admixture of 2 per cent. of breeze to the coal for carbonization did not adversely affect the structure of the coke, and an interesting point brought out in the report is that the breeze must be small and fairly dry for thorough mixing with the coal, which is an essential factor to success.

The result of breeze admixture with coal carbonized in the by-product coke oven plant at Rochester, N.Y., is that the surplus breeze has been reduced from an average of 1,000 tons to 140 tons per month.

Another very interesting development in American coke oven practice lies in the use of mixtures of producer and natural gas and propane air and coal gas for the heating of coke ovens.

Experiments have also been carried out on the heating of coke ovens with liquefied petroleum gas (propane air gas); these have shewn that, whilst this gas cannot be used solely, it can be successfully utilized in a two-thirds mixture with oven gas when the propane air gas is diluted to, approximately, 560 B.Th.U. In these experiments at Chicago it was found that the use of mixed gas required more careful attention to hold the battery in balance than with coal gas firing.

The use of these alternative methods of firing are entirely dependent upon local economic conditions, such as

plant arrangements, availability and price of fuel, coke and gas markets, &c.

(3) Water Gas.

The development of water gas plant practice is of vital importance in the United States of America, as this type of plant is used:—

(1) For the maintenance of gas supply in the event of partial or total interruption of the natural gas supply.

(2) For operation on peak days in order to even out the load factor on the natural gas supplies.

(3) For mixture with coke oven gas to balance peak loads where continuous supplies are purchased from by-product and steel works.

At the present time one of the main problems facing the gas industry in the United States of America is that of producing a high B.Th.U. gas in standby plants, *i.e.*, 100 per cent. interchangeable with the normal gas sent out whether it be natural gas only or a mixture with manufactured gas, and this problem is occupying a great part of the attention of the Water Gas Sub-Committee of the American Gas Association, and connected with it the subject of the satisfactory mixing of gases.

Complete automatic control of carburetted water gas plants, while by no means universal, is much more common in the United States of America than in this country.

At Montreal the Carburetted Water Gas Plant inspected consisted of 5 sets of 4 Mn. and 2 sets of 5 Mn. cu.ft. capacity, fitted with Western automatic controls; this control consists of a vertical cylinder under oil pressure, with ports at calculated distance along its length, which are opened and closed by a hollow piston in which there are corresponding ports; the piston makes one stroke per gas making cycle, and the oil pressure, which is maintained at 120 lbs. per sq. in., is communicated to the valves of the set.

The timing of the cycle is fixed by the relative position of the ports, but it was stated that variation could be obtained by adjustment of needle valves in the connection from the ports to the master valves.

A second type of Western control was seen at Baltimore, in which a balanced rotary four-way valve was used in place of the piston type; from this hydraulic valves were operated by a system of sprockets and chains. With this control the cycle can be easily modified, which is an important point when variations in quality are required in order to maintain a constant town gas, as is frequently the case in the United States.

Perhaps the most widely adopted control for automatic operation is the U.G.I. Control, which is similar in principle to that of Humphreys & Glasgow, Ltd., which is well known in this country; cams rotated by a constant speed motor operating pilot valves controlling hydraulically operated master valves on the C.W.G. set.

The feeding of C.W.G. generators in Canada and the United States of America is normal with that in this country except at Baltimore, where four sets are equipped with a charging machine for feeding the fuel without interrupting gas making operations. A single charging chamber with a flexible hydraulic connection is lowered from its wheels and clamped to the generator orifice. The chamber is fitted with an automatic weigher.

In the United States of America the water sealed type of self-clinkering grate is not favoured because high blast pressures are employed where the quality of the coke permits.

Automatic Control of Temperatures.

A considerable saving in time and fuel for the blast period is said to result by the application of a device for controlling the working of the cycle until the carburetter has reached the desired working condition of temperature. This device consists of a registering pyrometer, which, by a system of relays, starts the automatic controller when the desired temperature in the carburetter has been reached.

Waste Heat Boilers.

The use of waste heat boilers is general, and it is normal practice to fix one boiler to each C.W.G. set.

Carburetted water gas practice in the United States of America differs from that in this country for many reasons, a main one being the high blast pressure which is employed in view of the circumstance that the use of coke oven fuel is most general. Generators do not usually exceed 11 ft. outside diameter, *i.e.*, 9 ft. 0 in. inside of brickwork. Plants are usually of the three-vessel type, dome-topped generators, and carburetters with superheater. A cyclone dust catcher is usually fixed between the generator and carburetter.

The high blast pressures necessitate blowers being driven at high speeds with consequent greater use of steam. It is common practice to operate the steam turbines, and other steam-driven plant working in conjunction with the C.W.G. plants, with back pressure of 10 lbs. per sq. in. discharging into a steam accumulator, together with the steam from the jacket boiler where the set is so equipped. Steam accumulators of a low-pressure type are fitted to sets even in preference to waste heat boilers.

One very lasting impression of C.W.G. practice in the United States of America is the universal use of control instruments, recording and measuring air, steam volumes, temperatures, &c.

The Use of Heavy Oil in Place of Gas Oil.

The high price of gas oil resulting from the rapid increase in the demand for petrol has influenced the use of heavy bunker and residual oils for carburetting, particularly where such oils can be obtained at a comparatively low price relative to the cost of coal and coke.

The methods of best utilizing heavy oils have been, and are being, investigated by American gas engineers. There are several ingenious methods of carburetting which are successful in operation.

The principle employed is similar in nearly all systems, and consists of spraying oil into the top of the generator during the down run. In some instances, a proportion of pre-heated heavy oil is admitted to the carburetter during the up run.

The carburetted water gas resulting from the use of heavy oil is of lower specific gravity, and of lower CO content, as it is produced from less coke and more oil.

The economy to be derived from the use of heavy oil increases as the difference between the relative values of fuel and gas oils. It is interesting to note that the heavy oil produces double the amount of tar as compared with gas oil. The tar is very viscous when cold, and has a high water content, usually exceeding 40 per cent. Special drying processes are used, and the tar, when dehydrated, is stated, in some instances, to be suitable for road purposes.

Carburetted Water Gas of High Calorific Value as a Substitute for Natural Gas.

Extensive work is being done in developing and improving processes for producing a satisfactory high calorific value gas of 800 to 1,000 B.Th.U. in standard or modified carburetted water gas sets to augment natural gas supply, and to serve as a reserve against failure of supply. Mr. P. E. Eddy, of Chicago, Chairman, 1933, Gas Production Committee, in his Review of Developments in Gas Production, submitted at the Chicago Convention, A.G.A., stated:—"In my opinion none of the methods are to be taken as entirely successful or conclusive, as none of them have been operated for a sufficient length of time to be able to note the reliability of the process."

Oil gas is successfully used either for mixing with or as a substitute for natural gas during peak loads or emer-

gencies, and is produced by several processes operating on principles similar to those employed in the manufacture of water gas, which have been adopted and developed for this purpose.

Re-forming Natural Gas.

There are several processes in successful operation for the purpose of changing the calorific value and specific gravity of natural gas to conform to the town gas supply. At Chicago, natural gas was re-formed to producer gas to augment the coke oven gas contained in the town gas distributed. The process, in this instance, consisted of passing the gas to be re-formed through the chambers of the water gas plant during the steaming period, the gas to be re-formed passing through the generator, carburetter and superheater, or through the carburetter and superheater, only depending upon the degree of re-formation required.

(4) Condensation.

Water cooled condensers are in general use, and in the latest types the cross sectional area of the gas passes in a water tube condenser are reduced in proportion to the cooling of the gas in order to maintain a uniform velocity, and so secure higher efficiency.

At Philadelphia the water cooled condensers are supplemented by a refrigerating plant to cool one million cu.ft. of gas per hour down to 40° F. The primary object of this plant, the operation of which varies with, and is dependent upon, the temperature of the cooling water in the main condensers, was to reduce gum formation.

The condensing of C.W.G. is frequently carried out in conjunction with scrubbing by direct contact between the hot gases and the cooling water.

(5) Tar Extraction.

This is usually affected by electrical precipitation; this method is becoming almost standard practice.

(6) Exhausters.

Turbo exhausters are almost exclusively used, and are very frequently electrically driven.

(7) Purification.

Purification, in the majority of gas plants, is carried out in dry boxes. Considerable progress has been made in liquid purification processes.

A process which is largely adopted in connection with coke ovens during the past ten years is that in which the crude gas is washed with sodium carbonate. The liquid purification tower used for this purpose is divided into two compartments, both packed with wooden grids. The H_2S is absorbed in the upper compartment with fresh soda solution sprayed in at the top whilst soda solution is activated in the lower compartment by means of air blown through and recirculated. The foul air from the actifier is carried forward to the coke ovens where the H_2S is burnt to SO_2, and in this form escapes to atmosphere.

The Soda Thylox Process has been in commercial operation for some years in a number of plants. The active compound in the Soda Thylox Process is sodium thioarsenate, from which the free sulphur content is eventually recovered as Thylox Sulphur or as brimstone. It is said that this process consistently removes 99 per cent. of the H_2S from the gas.

A recent development is the Ammonia Thylox Process, which is an outgrowth of the Soda Thylox Process; in this ammonium thioarsenate is used as the reactive agent. The absorber is placed after the saturator in the gas system of the coke plant. The Thylox solution is circulated continuously first through the absorber, then through an actifying tower, in which it is revivified by blowing it with air. The air releases sulphur from the solution, and carries it to the top of the tower, where it is separated in a skimming tank as a thin slurry.

It is claimed that some of the sulphur removed from the gas, but not recovered as such, combines with the hydrocyanic acid present in the gas to form thiocyanates, thus removing about 90 per cent. of the hydrocyanic acid which is such a serious cause of corrosion in the distribution system. The last traces of H_2S remaining after liquid purification processes are removed in oxide catch boxes.

An interesting feature in connection with purification is the general use of inert gases for the purging of purifier boxes before being put out or into service. The purging machine commonly used is a plant which collects the products of combustion from an appliance in which gas is burnt with the approximate theoretical quantity of air, the cooled products then being used to displace the gas in the purifiers or other vessel to be purged.

This practice is worthy of consideration for general introduction in this country, as it removes any risks of explosion.

(8) Oil Washing for the Removal of Benzole from the Gas.

Gas washing for benzole is generally carried out in vertical scrubbers of the revolving tray or ordinary grid filled type.

It is common practice, both in Canada and the United States of America for condensers, scrubbers and washers, and, in fact, all purification plant to be housed on account of the rigorous winter conditions. These houses are usually of the stage floor type, so that all connections are above ground and easily accessible.

CONCLUSION.

Gas production in Canada and the United States of America, so far as carbonization is concerned, does not differ materially from British practice. Methods generally, however, must of necessity vary considerably by reason of the natural gas resources and consequent economic conditions, and the delegation found many interesting practices and developments which engender new thoughts and inspirations, and this Communication attempts to indicate some of these.

There appeared to be a consensus of opinion in the United States that, as a result of the ever-increasing price of oil, carbonization will eventually prove to be the most economical method of gas manufacture, particularly in those areas in which cheap coal is available, and there is a sustained demand for coke for domestic and industrial purposes.

In ancillary plant, progress has been more rapid than in this country. Liquid purification by the ammonia, sodium carbonate, and other processes continues to make progress. Electric tar separators have become almost standard equipment; automatic control and mechanization of processes is well developed. The use of control instruments is much more general and tends to the better control of manufacturing operations. In this latter connection, mention should be made of the excellent progress that has been made in the last few years in the science of gas mixing.

A most interesting contribution, describing the gas mixing and conditioning plant of the St. Louis County Gas Company, was submitted by Mr. O. R. Allgeier at the Chicago Convention of the American Gas Association.

[By the courtesy of the American Gas Association this was reproduced as an Appendix to Col. Carr's paper. In the author's view a careful study of these developments inspires the thought that our methods of mixing, and balancing of mixtures, of straight coal gas and carburetted water gas are capable of considerable improvement.]

All members of the delegation were inspired by the vitality of the Gas Industry throughout the continent of America, and impressed by the co-ordination within the Industry itself.

The progress and information recorded annually by the American Gas Association, in which all common interests are merged for the common good, engendered the admiration of all members of the delegation, and inspired the hope for similar co-ordination and co-operation at home.

2—Distribution and Utilization

By C. A. MASTERMAN, M.A., F.I.C.,

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PRICES AND COMPETITION.

Cost of Living.

It will be convenient in this report to consider any prices or costs in terms of English currency at the parity rate of exchange prevailing at the time of the visit. Bare existence could be maintained at a not very dissimilar minimum figure in Great Britain and in America. The normal standard of living in the latter country is, however, very much higher, and wages and salaries for comparable work are on a proportionately higher scale. Thus, while the average annual American gas bill *per capita* is larger than in Great Britain it represents a smaller proportion of the normal family budget.

Price of Gas.

Expressed at parity exchange, the prices of manufactured gas are comparable with British prices, but are generally based on a more flexible rate structure, while the average price for natural gas is very substantially less on a volume basis, and still more so if converted to a thermal basis. Only in exceptional cases is the thermal basis of charge in operation as in Chicago, where its introduction facilitated the change over from manufactured to mixed gas of higher Calorific Value. The introduction of natural gas, sometimes conveyed by pipe lines over great distances, presents a special problem in rate fixing especially when, as at Chicago, the pipe line is working under capacity. To effect economical transmission, a steady demand of 15 million cu.ft. a day can be accepted at 1½d. per therm pending more lucrative outlet.

Coke.

Of the total gas production for the country, only about one-third is manufactured gas, and of this a proportion is coke-oven gas. The supplies of coke are, therefore, very much more restricted than they are in Great Britain, the demand, for climatic and traditional reasons, is greater, production is controlled, and good prices can be maintained. For two years total gasification (carburetted to 500 C.V.) was carried out at Montreal, but coke-oven plant is now in operation and large stocks of coke were visible.

Electricity.

Large scale hydro-electric development in Canada has stimulated acute competition, the price of current for power and large quantities sometimes falling to 0·2d. per unit (*e.g.*, Montreal). In the United States, with less water power available, the prices of current generally appear to be not less than those common in London, and for heating purposes competition from this source appears less acute. This may be due in part to a planned policy of allocating the power and lighting load to electricity and the heating load to gas—over 40 per cent. of the manufactured gas being supplied by combination companies which control the supply of both gas and electricity.

Bottled Gas.

Propane and butane are distributed in cylinders or tank waggons to isolated customers, but competition on a price basis is virtually non-existent where town's gas is available.

Coal and Oil.

The scale of the country is so large and distances so great that the supply and prices of coal and oil vary very widely from place to place.

Competition with gas is sometimes acute and counter measures sometimes rely rather upon the creation of special tariffs than upon increasing the efficiency of the gas appliances by which within limits such competition can better be combated.

In some cities the use of raw coal is restricted in the interests of smoke abatement, a legislative control favourable to the local gas undertaking and one very visibly contributing to the local amenities.

Steam.

Low and high pressure (5 lbs. and 100 lbs.) steam distributing systems using insulated pipes are in operation for heating purposes in certain cities, a method of charge being by the collection and measurement of the condensation.

ORGANIZATION AND POLICY.

Organization.

The highly decentralized American scheme of organization does not appear to be inconsistent with the maintenance of a common policy within the undertaking. Considerable subdivision of organization is noticed both on administrative and functional lines. The outdoor selling staff is usually independent of the outdoor operating staff, and specialized groups are responsible for individual applications of gas, such as central heating, refrigeration, &c. The fact that the number of employees per unit of gas sold does not much exceed half that in Great Britain is probably less due to extreme mechanization than to the assistance rendered by outside contractors, both in installation and maintenance work and in the selling of appliances. The function of the undertaking is sometimes confined to notification, quick delivery of the required appliance, and final inspection of the completed work. Considerable sales importance is attached to this close co-operation, which does not, of course, remove from the undertaking its direct responsibility to the consumer.

Personnel.

The proportion of technically competent individuals in all sections of the gas sales departments appears to be very high. In some undertakings training is continually in progress, covering both technique and salesmanship, and interdepartmental visits are regarded as of value.

Commissions on sales, based either on appliance selling price or on estimated gas consumption, or both, appear almost universally to be paid both to outside contractors and to undertakings' employees. It is possible for a successful salesman to earn a comparatively large amount in addition to his basic salary, which salary may not itself be much above that for corresponding work in Great Britain.

Service.

Appliances are generally supplied on sale or on some form of deferred payment terms often inclusive of charges for installation. Hire is less frequent than in Great Britain, but is on the increase. Regular maintenance inspections are not universal except in the case of very large consumers, but considerable ingenuity has been expended to ensure that the consumers' requirements or complaints receive immediate attention. In Philadelphia, for instance, the consumer ringing the undertaking on a service line speaks to a specialist operator. If he cannot deal with the inquiry personally, he connects the appropriate department and individual to the same line, and a three-cornered talk ensues without break in the continuity of the consumer's explanation or need for unnecessary repetition.

Control of fitters and personnel on the district is commonly exercised by telephone.

Mechanical transport is sometimes provided, with the

help of which it is stated that in Montreal maintenance men make twenty-five calls in an eight-hour day compared with fifteen calls using a hand truck.

Gas Associations.

Both in Canada and the United States there is a central Gas Association, the Canadian Gas Association being affiliated to the American Gas Association. These central bodies are maintained by levy on the undertakings based on 1d. per consumer *plus* contributions from the manufacturers of gas appliances and apparatus. Membership is open to any individual connected in any way with the gas industry regardless of qualification or position. An immense amount of information is co-ordinated by the Association and can be obtained by the undertakings, supplemented by personal contact with the various expert officials of the Association.

Throughout the industry the gas sales side gives the impression of confidence derived from adequate resources in men, organization, information, and material.

LABORATORIES AND RESEARCH.

Research on gas utilization problems is in progress at several centres (*e.g.*, Toronto, Baltimore), and in the laboratories of the contractors, of the undertakings, and of the American Gas Association.

A.G.A. Laboratories at Cleveland.

Among the laboratories visited were those of the A.G.A. at Cleveland. Much of the work is concerned with the testing of domestic and industrial gas appliances of all kinds to rigid standards evolved after full discussion in committee. Particulars of the tests are published and cover combustion (450 C.V.-1,150 C.V.) efficiency, fire hazard, constructional details, &c. On a cooker alone, about 167 separate tests are involved at a cost of about £40. Cost of testing is covered by the fees payable by the manufacturer submitting the appliance, who is not permitted to be present during the test. If the appliance passes the tests it is permitted to carry the A.G.A. Seal of Approval badge, which is now familiar to the American public, and without which sales of an appliance are likely to be very restricted. The works of manufacturers of approved appliances, of whom there are about 250, are visited annually by inspectors of the Laboratory to ensure conformity of the equipment to that originally tested and approved by the Laboratory.

Of the annual operating cost of about £30,000 about half is provided by the testing fees, and the remainder consists of grants from A.G.A. headquarters earmarked for research into defined problems, such as methods of jointing mains, elimination of burner noise, or furnace recuperation. This research is under the control of committees, and the results, which are published, assist both the undertakings and the contractors. That the spirit in which these laboratories were founded is no sectional one is indicated by the inscription at the door: " To promote and develop the gas industry to the end that it may serve to the fullest extent the best interests of the public."

Laboratories of the Undertakings.

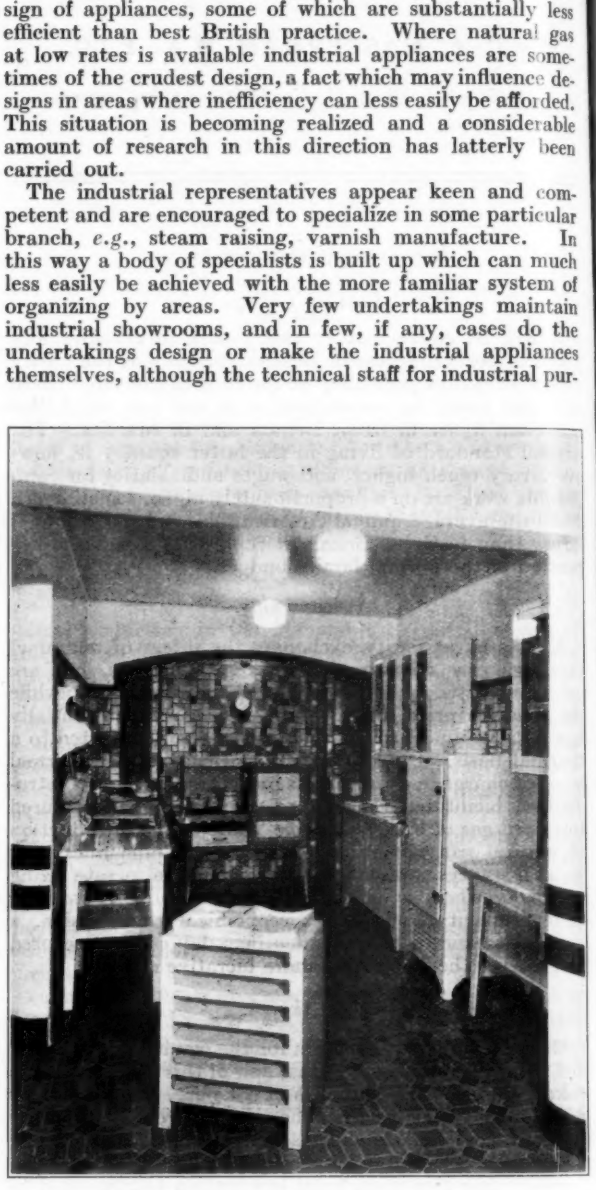
The A.G.A. certification of appliances has not wholly superseded the need for further test by the undertakings, some of which maintain gas utilization laboratories for this purpose and for dealing with day to day technical problems. There is often close co-operation between these laboratories and the appliance manufacturers in the development or improvement of appliances, &c.

GAS APPLIANCES.

Industrial.

A number of industrial and semi-industrial gas installations were inspected, including light and heavy metal processes, paint and varnish work, preparation of food products, &c. It is only the availability of natural gas at very low rates which makes it economically possible to use gas for certain of these processes (*e.g.*, strip mills). Where manufactured gas only is available and the prices are consequently comparable with those in Great Britain, competition with fuel oil is often severe. Generally speaking, if the price discrepancy exceeds 25 per cent. the chance of obtaining or retaining the gas load is regarded as not good unless the load is of a special character for which gas is peculiarly suitable. Concentration is directed rather towards adjustment of prices than to design of appliances, some of which are substantially less efficient than best British practice. Where natural gas at low rates is available industrial appliances are sometimes of the crudest design, a fact which may influence designs in areas where inefficiency can less easily be afforded. This situation is becoming realized and a considerable amount of research in this direction has latterly been carried out.

The industrial representatives appear keen and competent and are encouraged to specialize in some particular branch, *e.g.*, steam raising, varnish manufacture. In this way a body of specialists is built up which can much less easily be achieved with the more familiar system of organizing by areas. Very few undertakings maintain industrial showrooms, and in few, if any, cases do the undertakings design or make the industrial appliances themselves, although the technical staff for industrial purposes is larger than in British undertakings. Poster publicity for industrial jobs is commonly synchronized with a planned campaign of industrial development.



A Demonstration Kitchen, New York.

Of manufactured gas the proportion used for industrial and commercial purposes to the total sold appears very much less than that in Great Britain, but of natural gas, as might be expected, the reverse is true.

Lighting.

Considerable interest was expressed in the maintenance of the lighting load and the development of gas flood lighting in Great Britain. Regret was expressed that gas lighting had practically ceased to exist in Canada and the United States. A few gas street lamps were seen, these having upright mantles in indifferently designed housings.

Refrigeration.

The ice box habit was firmly established many years ago in Canada and the United States; ices and ice pud-

dings, ice water and iced drinks both legally soft and illegally (1933) hard are universal.

The gas undertakings organized to sell gas refrigerators on a large scale, and these efforts have met with very considerable success. The gas refrigerators appear to be entirely of one type, familiar in Great Britain, and are sold inclusive of special servicing or with special price concessions regarding replacements. A strong selling point is the all-in guarantee for a period impossible with the electric type.

Over 200,000 gas refrigerators are said to have been installed in New York alone.

Water Heating.

The water heating load is an important one, and gas for this purpose is generally supplied at greatly reduced prices. The appliances used are of the storage type or are coil heaters to be connected to an existing system. The standard of appearance and finish of some of these heaters is inferior. Most house water installations are directly connected to the main, and few, if any, geysers are used.

The normal design of American house is said to involve hot pipe runs so short that lagging is unnecessary. A basement is usually available to accommodate the combination storage set.

Gas operated wash boilers are unknown. Agitation rather than boiling is relied upon in house laundering, and washing machines are the rule. A washing machine with gas burner attached for topping up was on display in New York, the cost, including motor, agitator, and electrically operated wringer, being about £10 in the smallest size.

House Heating.

Central heating by hot air, hot water, or steam radiators has long been established in Canada and the United States as the normal method of house heating. For this, the extreme climatic conditions and the popularity of the "apartment house" are probably responsible. Standard American comfort conditions would be considered stuffy and hot in Great Britain. Technical opinion favours heated and conditioned air as the systems most to be preferred, and does not accept panel heating as likely to prove satisfactory under American conditions.

As with refrigerators, the undertakings have organized themselves to be specially capable of installing and servicing gas central heating systems. Installations or conversions were said to be in hand in Chicago at the rate of about 200 a day, and standard tests by the undertaking's engineers had necessarily to be relaxed to the point when flue gas analyses alone were carried out on completion of the job. As a result many complaints had been received.

The central heating units used are of normal type, but embody aerated flame burners. For conversion purposes on solid fuel boilers aerated flame burners with refractory brick settings are commonly used. No satisfactory reason could be found for the adoption of such relatively expensive sets compared with plain luminous burners, but it may be due to the very inefficient design of certain of the solid fuel boilers in which the sets are fitted.

Remote control thermostats appear universal, and the gas heating units are fitted with many ingenious automatic devices.

Condensation and corrosion in the flues attached to gas central heating units are familiar, and various antidotes have been developed, *e.g.*, sprayed linings in Toronto, glazed linings in Pittsburg.

In Canada very few gas fires are displayed, but further south some gas fires and portable gas heaters are to be seen in the showrooms. These fires are unimpressive in appearance, but in some cities are used without hesitation as flueless appliances.

The Rector System of vacuum gas radiators is still used in Vancouver, but apparently not elsewhere.

Cooking.

Domestic cookers are the most conspicuous appliances in the showrooms, reflecting the fact that in the Cleveland Laboratories three times as many cookers are tested as all other types of appliances put together. Nearly all domestic cookers are in the form of ranges, the normal British type having a single oven almost at floor level being the exception. Construction is in stamped steel, with white or cream vitreous enamel finish, and the better class cookers are estimated to give satisfactory service for 10-15 years. The appearance of the typical American cooker, with its smooth surface and totally enclosed shell, is most attractive, and in the cheaper varieties serviceability has perhaps been sacrificed to comeliness.

The hotplate burners are less efficient than British patterns since flame contact is rarely achieved, the design probably being influenced by the necessity of accommodating natural gas of high calorific value. There has recently been introduced an annular burner with removable centre, having something in common with the British ring burner, and this is said to be likely to become popular.

Self-ignition of the hotplate burners by pilot or flash is almost universal, but the hotplate accommodation in relation to oven size sometimes appears limited. Grillers are not used on the hotplate, but, in the form of broilers, are usually to be found in a compartment near the base.

Plate racks are rarely fitted, but often a sliding or hinged plate can be drawn over the hotplate when not in use.

Both lagged and unlagged ovens are sold, spring catches generally being provided to mitigate, it is said, the effect of oven explosions. Thermostats are commonly used, and clock control for the automatic switching on and off of the oven at predetermined times has recently been introduced. The latter costs about £8, the cost of the cookers being approximately double British prices. These high prices may in part be due to the heavy factory overheads in respect of tools, presses, &c., spread over inadequate numbers.

Royal York Hotel, Toronto; Gas-Fired Convention Hall Kitchen.

Some undertakings allow considerable discount in respect of old gas cookers returned to them for scrap (*e.g.*, Ottawa up to £2).

Restaurant cookers in black, cast or semi-cast construction, shew less contrast with British patterns. Some ingenious restaurant appliances have been developed, among them an automatic toaster with electric drive selling at about £40 for a capacity of 200 slices of toast per hour.

Gas appears to be almost universally used for cooking, and all the hotels at which the Institution party stayed were served from gas kitchens. At Niagara every hotel kitchen is said to be gas-operated, while at this centre of hydro-electric development the provision of gas in the kitchens of private houses is sufficiently popular to merit special mention on the notice-board advertising such houses "for Sale."

Miscellaneous.

Gas-operated drying cabinets appear to be popular, and a gas operated hair drying appliance has been developed.

Incinerators are shewn in showrooms, but apparently are rarely used except in remote parts of the country where difficulties arise in the collection of refuse.

Very few of the small portable gas appliances which are familiar in Great Britain appear to have been developed in America or Canada. The gas iron has been wholly supplanted by the electric iron.

DISTRIBUTION.

Meters.

Meters are standardized in size and dimensions simplifying renovation and repair, a matter of special importance in view of the legal requirement that they should be withdrawn for examination and test after a limited number of years, *e.g.*, Canada every 6 years; United States, 3 to 7 years (subject to local state legislation). It is reported that about 70 per cent. of the meters are found to be accurate on this retest.

The most popular size domestic meter appears to be 150 cu.ft. per hour, operating at full capacity at 900 revolutions per hour.

The use of semi-chrome leathers for diaphragms is increasing, and the bag type is entirely universal.

Direct reading indices are not yet general but are stated to lead to better "public relations." For a variety of reasons the use of slot meters is discontinued, but latterly, *e.g.*, in Boston, the use of these meters shews signs of revival. Monthly accounts are the general rule, but meter rentals are not always charged, *e.g.*, Baltimore.

In some cities the margin of inaccuracy allowed on meters is as small as ± 1 per cent. compared with electric meters of ± 4 per cent., these limits requiring especial precautions in the manipulation of the test holder, &c.

The meter bar in some form appears universal, and has reflected upon design of meters in that these are made with specially reinforced connections. This contrast with British practice may in part be due to the necessity in apartment houses of accommodating a large number of meters in a relatively small space.

Distribution System.

Distribution is generally on the high low principle, involving a low pressure system (5 or 6 in.), reinforced by a high pressure feeder line at 5-12 lbs. per square inch. Transmission of natural gas for long distances, *cf.* Panhandle, Texas, to Chicago 1,000 miles, may involve pressures as high as 600 lbs. per square inch.

In city systems extensive use is made of valves for the cutting out of sections, &c.

Steel mains with welded joints or mechanical couplings are used and cast iron mains with mechanical joints of the Dresser or McWayne type are also common. On old pipe lines ring bolt joints with lead faced rubber rings are superimposed over the old jointing material. In Montreal the joints are run with cement, a system not generally adopted elsewhere.

Labour saving machinery is extensively employed in the laying of mains, and for service replacements machines are used for driving or drawing the old pipe and replacing by the new without breaking the ground surface, *e.g.*, Philadelphia and Baltimore.

Gas Quality.

The control of gas quality appears less stringent than in Great Britain, both in calorific value and composition. Gas is required to carry a characteristic smell and synthetic compounds have been used to fulfil this requirement. In some places, pure carburetted water gas has been satisfactorily supplied for years, early attempts to legislate regarding carbon monoxide content having led to investigations, as a result of which "the public authorities came to the conclusion there was no logical ground for legislative interference."

The gum problem has occurred sporadically, and in some places acutely, but no unified research regarding cause and antidote appears to have been carried out. Spraying has been tried with uncertain result, and a special labyrinthine pilot has been developed which it is claimed is proof against choking by gum. Such a device, however, is not of universal application to all the many and varied controls at present in use. One undertaking was reported as reviewing intensively its methods of gas production with a view to eradicating gum at source.

It was reported that luminous burners in appliances are unsatisfactory on the general gas quality supplied, but no explanation is furnished as to the cause.

Two-thirds of the gas supplied in the United States is natural gas drawn from accumulations in porous rock sometimes many hundreds of feet beneath the surface. The calorific value is usually about 1,000. The gas consists of approximately 80 per cent. methane, contains no carbon monoxide, has no smell, and requires no purification. The wells are by no means inexhaustible and are of varying capacity. (A single well near Pittsburg blew initially at 63 million cu.ft. daily.) In certain cases exhausted wells are used as holders to contain excess production of natural gas, which is pumped into the well and subsequently recovered when the gas demand has caught up with supply.

The availability in America and Canada of natural gas in large quantities introduces a factor which has no counterpart in British practice.

3—Administration, Accounting, and Publicity

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ADMINISTRATION.

The American Gas Association.

The American Gas Association, which is the National organization of the American Gas Industry, carries on its work through Sections and Committees, whose activities cover all departments of the Industry, including Rate Fixing, Publicity and Advertising, Industrial Development, Distribution, Accountancy, and Research.

The American Gas Association comprises the Gas Companies, the manufacturers of equipment and appliances, and individual members, and has its affairs administered by an Executive Board which, when the Annual Convention is not in session, has exclusive jurisdiction over all the affairs appertaining to management and the permanent Staff. The latter are specialists in every phase of the Industry, and are under the direction of Major Alexander Forward, the Managing Director.

Briefly, the American Gas Association's organized activities provide for:—

1. Co-operation within and without the Industry on all matters affecting the manufacture, distribution, and utilization of gas.
2. Proper rate structures and their application.
3. Improved selling methods and stimulation of selling efforts.
4. Greater understanding and appreciation of gas service.
5. Campaigns for advertising in trade journals and attention to national advertising.
6. Educational campaigns.

7. Support of Courses in Gas Engineering and Fellowships in educational institutions.
8. Technical research.
9. Support of the Testing Laboratory.
10. The study of the subjects of asphyxiation and resuscitation.
11. Co-operation with manufacturers' representatives and other interested bodies.
12. Statistics and an Information Bureau for the needs of the Industry.

The American Gas Association, besides publishing its own proceedings, is responsible for two monthly magazines—the *A.G.A. Monthly* and *Natural Gas*.

There is nothing haphazard about the work and activities of the A.G.A. which, by co-operation and co-ordinated efforts, is doing excellent work for the Industry and, by presenting a unified front, appears to have many advantages over our various organizations in their present form. The individual undertakings look to one powerful Association for guidance, with the result that there is considerable uniformity of the bases for gas charges (or rate fixing) as compared with the diversity of methods adopted in this country. Also, owing to the work of appropriate Committees, their selling methods, systems of record and accountancy procedure are of the greatest practical value to the Industry and are in advance of those in this country.

In this country a very wise step in the direction of unification was taken recently by the formation of a Joint Co-ordinating Committee, representing the three National Gas Organizations, and the advisability of giving this Committee the greatest support cannot be emphasized too strongly. It may not be opportune at present to suggest the merging of the existing National Organizations (including the Society of British Gas Industries) into one Association for the Gas Industry of Great Britain and Ireland, with appropriate Committees operating on the lines of the American Gas Association, but the impression formed by many members of the Delegation, who had an opportunity of taking part in the proceedings at the Annual Convention of the American Gas Association and of seeing some of its work in detail, was that such unification in the Gas Industry here would be of inestimable value to all concerned.

Growth of the Gas Industry.

In common with most other business activities, the Gas Industry was affected in the three years 1931-33 by the unparalleled general economic and industrial depression. However, in comparison with other industries, there was again demonstrated that inherent soundness which is a feature of the Gas Industry, both in America and in this country.

In spite of the temporary set-back in the depression years and of the increasing competition from other forms of lighting and heating, figures shewing the growth of the Industry in Canada and the United States indicate that their progress compares very favourably with our own. This is particularly impressive when one remembers that electrical competition is even more intense in both those countries, and that, in Canada particularly, electricity is considerably cheaper and the population more "electrically-minded" than in this country.

State Commissions and Control.

Government control (which is comparable with our own Special Parliamentary Acts and Orders and supervision by the Board of Trade) is exercised by statutory enactments imposed by State Commissions, the members of which are appointed by the Governors of the various States.

The United States of America is a collection of separate units, each having its own legislatory powers, and whilst the supervision, to some extent, is national, the main negotiations are between the Commissions and the representatives of the Utility Companies in each State. Fortunately, the State Representatives on the Commissions and the Executives of the Public Utility Companies work harmoniously together, and the impression formed is that the Industry as a whole is less hampered by government restrictions than is the case in this country.

So far as individual control of gas undertakings is concerned, it is interesting to note that very few are municipally owned and that in both Canada and the United States there are numerous cases of the same undertaking supplying electricity as well as gas. It has become recognized that it is for the general benefit of the community that the supply of the two commodities should be placed under one control, thereby avoiding the considerable duplication of costs in running two distinct organizations. So much is this the case, that such combinations are not now discouraged by the authorities, and, in discussing this question with those in charge of the combined supplies, it was argued by them that the advantages of combination were so great that any possible disadvantages due to the suppression of competition were insignificant. It is claimed that co-operation and joint working have eliminated unnecessary expense and enabled the Combined Companies to place before the public a properly balanced opinion of the respective fuels.

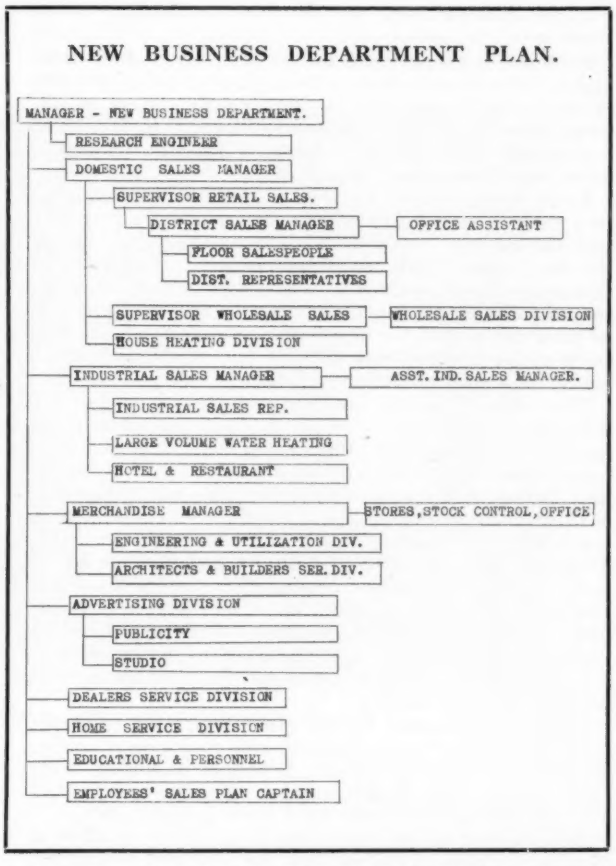

Chart 1.—*Organization, New Business Department, The Brooklyn Union Gas Company.*

The policy of controlling groups of undertakings by one large Holding Company is adopted more generally in the United States than in this country. It is stated that the Holding Company, when legitimately operated, is an effective means of strengthening and improving the general position of the undertakings and, at the same time, of assisting to reduce the price of the commodity. In many cases, however, acquisition by such Holding Companies has led to an inflation of capital, and has not proved helpful in the development of the gas undertakings concerned.

On this subject of control the organization of the Brooklyn Union Gas Company, New York, was particularly interesting. It has been realized in the United States for some time that, in this age of intense competi-

tion, specialization is very necessary, and reference to the New Business Department's plan of organization, Chart 1, will shew that competent members of the Staff are fully occupied in separate sections of the Sales Department. Under the Manager of the New Business Department, there are sectional leaders, such as Research Engineer, Domestic Sales Manager, Industrial Sales Manager, Advertising Expert, &c. Whilst one or two large companies in Great Britain have similar arrangements it is felt that medium-sized undertakings would benefit considerably by following the methods of the American companies. It is probable that distribution costs and overhead charges would be increased, but better service to the various classes of consumers would result and add to the certainty of the Sales Service—which is one of the most telling factors for success in Industry to-day.

The majority of undertakings in America appear to plan their business on scientific lines. In this respect they are in advance of many of those in Great Britain.

ACCOUNTING.

Accountancy and Mechanical Aids.

In America prepayment meters are very seldom used, and it seems strange that in Chicago, with nearly 900,000 meters in use, there are no prepayment meters at all. This, however, is not peculiar to Chicago. In fact, few, if any, slot meters are to be found in Toronto, Brooklyn, or in any of the other cities visited.

From conversations on this subject, it was gathered that the non-use of prepayment meters is due to the fact that the average gas bill is high in amount, and that in the days when prepayment meters were employed the Companies were troubled to a serious extent by damage to and pilfering of cash from meters. Another objection to their use is that the law in the various States is such as to make it sometimes difficult to obtain payment of debts, or a conviction for pilfering.

The ordinary meters are read monthly, and, coupled with Monthly Billing, this system has been adopted almost universally. It was explained that if the period were extended to three months, bad debts would be considerably increased, because of the difficulty of keeping trace of their customers, who appear to change their residences much more often than householders do in this country. Therefore Monthly Billing, with its costly necessity of meter reading, account recording, &c., twelve times per annum instead of four under the Continuous and Quarterly Systems, appears to be the method best suited to Canada and to America, but there are no similar circumstances in this country which would warrant the general adoption of that method.

Domestic appliances are not generally let out on simple hire, the majority being sold to consumers on a twelve months' hire purchase basis. It should be added, however, that a much larger number of appliances is sold for cash than is the case in most areas in Great Britain.

With regard to gas accounts, it is usual to allow a discount as high as 10 per cent. for payment within ten days. This shews again that the undertakings appear to be apprehensive as to the financial stability of their consumers.

Mechanical aids in Accountancy work appear to be general, and machines and systems, similar to those adopted by many Undertakings in this country, are in use, but mechanization in their Offices has advanced much further. In addition to the Rentals, Monthly Billing, and Hire Purchase Records, practically all entries are performed by machines, including postal franking, the keeping of pay books, stores records, and sales analyses. Further, conveyors or carriers are used to transport small order cards and instruction forms from one department to another. In this respect, the impression was formed that mechanization had been overdone, and considerable capital outlay entailed without having effected a corresponding saving in overhead expenses.

In the larger companies in the United States, workmen are paid by cheque, which can be cashed at any Bank on production of an identity card.

Price of Gas and Methods of Charge.

The price of gas both in Canada and in the United States is higher than in Great Britain, which is mainly attributable to the following reasons:—

(1) Wages, all round, are higher in both those countries, therefore it follows that the cost of manufacture and distribution is greater, but this is offset by the correspondingly higher incomes of the consumers.
(2) The higher cost of coal, because of the expense of transport over greater distances.
(3) Although the Industry benefits by the large quantity of natural gas available, considerable outlay is involved in conveying the gas to the cities using it.
(4) The higher oncost entailed by the employment of a greater number of officers and executives all of whom are in receipt of higher salaries, but which is undoubtedly offset by better service to the consumers.

August, 1930, witnessed the inauguration of billing customers on the thermal basis, and many of the larger companies have now adopted this system. The method of charge differs from that adopted by the majority of undertakings in this country; both in Canada and in the United States, two-part tariffs are common, and, in many cases, three and four part tariffs are used.

Gas rates (prices) are regulated by a Public Service Commission which functions in each State to administer the public service laws. The rates which may be charged are usually based on a figure sufficient to enable a public utility company to realize a fair return upon its capital, or on some other reasonable basis approved by the Commissioners.

In the case of a two-part rate, a careful analysis of the costs of the Company is necessary in order to compute the Service and Commodity Charges. In industrial service a Demand Charge is in use, which permits the customers with high load factors to obtain a lower average price, and enables the gas company better to meet competition.

Both in Canada and in the United States, owing to extremes of temperature, central heating of houses is almost universal, and many gas undertakings quote special rates for this load, the consumption being recorded on a separate meter. It is interesting to note that meter rents are not charged separately in either country, and also that most domestic rates for gas service (at any rate in America) contain a minimum charge provision.

The American Gas Association has a Bureau which advises companies on the formation of rate structures, and through experts assists any Company which is about to apply to the State Commission for a two, three, or four part tariff.

All proposed rates or alterations, whether in methods of computation or amount, even when a reduction is involved, have to be filed with the State Commissions, and the A.G.A. is willing to send an expert to assist the gas company in convincing the Commissioners that the proposed charges are equitable.

Although the advantages of transcontinental methods of charge for gas are apparent, such methods could not easily be adopted in this country owing to the restrictions imposed by our legislation. As you are aware, a sliding-scale company is not in a position to adopt a two, three, or four part tariff, owing to the dividend payable being controlled by the charge for gas in relation to standard price. As it stands now (March, 1934) the Gas Undertakings Bill, 1934, does not give the Industry all it considers that it is entitled to in this respect.

The methods of charging for gas are of the greatest importance to us at the present time, and, until relaxation of the legislative restrictions is obtained, undertakings will be in an unfavourable position, and, generally, will be unable to offer special contract rates to induce consumers to use gas more extensively. Everywhere in Canada and in the United States tariffs (approved by the

Commissions) are in force, designed to meet competition and to attract new business, and, in this direction, both countries have been particularly successful.

PUBLICITY.

Competition, Publicity, and Propaganda.

The combined control of Gas and Electricity is not without certain defects; for example, in some concerns it would appear that it has been thought expedient to hold back the fair development of the appliances for one or the other fuel. Electric cooking shews signs of progressive development, despite its having been held in the background. There are three reasons, however, which will prevent the rapid increase in the number of electric ranges in use:—

(1) The operating cost is greater than by gas.
(2) Electric ranges cost more than gas cookers.
(3) Cooking is not done so quickly with an electric as with a gas range.

It is realized that each of these handicaps may be diminished, if not removed, and the Industry is preparing for vigorous competition in this field. There is appreciation of the necessity of still further improving the appearance, efficiency, and prime cost of the gas cooker.

It was readily seen that the Canadian and American Gas Companies had realized for some considerable time the great importance of creating and maintaining friendly relationship with their consumers, and no opportunity of furthering this feeling is lost.

With regard to showroom accommodation and the personnel of the staff, the sales side of the Industry is well equipped. The salesmen, who are chosen with care, are alert and fully trained, and nearly all of them work on a salary *plus* commission basis. The showrooms, which are situated in the best shopping centres, are fitted up in an excellent and complete manner, and without exception are provided with a large well-furnished hall to accommodate 100 or more persons. In many cases, gas cookery lectures are given daily.

Every large company has in operation what is known as a " Home Service " department. This is an important side of the American organization, and consists of a number of highly trained women who, by giving lectures and demonstrations, keep in touch with the consumers. In addition, they follow up the sales of appliances by giving instructions regarding their use in the homes in which they are fitted, and generally render assistance in planning kitchens and making the use of gas as attractive as possible. This special department also advises concerning parties or similar functions, held at consumers' homes, and often an assistant is sent along to supervise the preparations.

In a prominent position in the main office of the gas undertaking at Chicago is a counter devoted entirely to the " Home Service " section, and each day at a specified hour the Chief of the Section interviews consumers, answers inquiries, and gives advice. There are also certain " dishes " cooked, and samples and recipes handed round. In the chief showrooms there is a lecture hall provided with accommodation for 700 people. This is equipped along the sides with different kinds of model kitchens to suit all classes of the community, and there is an Inquiry Office at the entrance where recipes and menus are distributed. The entire organization is in the charge of a woman expert.

These lecture halls are sometimes engaged for what, in Great Britain, would be considered unusual purposes. For instance, a consumer may, by arrangement, use the hall for a bridge party, lecture, or demonstration of some kind, or for any social function, on the understanding that the hostess and her guests will be willing to listen to a short talk on gas appliances. An endeavour is always made to blend these informal talks with the aims of the particular function and to avoid making the gas propaganda too obvious. The Company sometimes arranges to supply the refreshments, and thus obtains further advertising benefit in demonstrating the quality of gas-cooked food.

First Floor Showroom of the Boston Consolidated Gas Company.

In the matter of general advertising, the methods adopted in Canada and in America closely resemble our own. Newspaper advertising and the sending out of leaflets with accounts, &c., chiefly being adopted. The Gas Associations appear to do more than the British Commercial Gas Association, and supply their members with large quantities of powerful and effective material for publication. Large-sized posters are shewn on hoardings in nearly every town, and the radio is frequently used at considerable expense for bringing before the public the advantages of gas and the various appliances.

It can be well imagined that the sales service and propaganda referred to has made the housewife in Canada and in America much more " gas-minded " than she is in this country, and, although the cost to the undertakings is appreciably greater, the expenditure has shewn satisfactory results.

Appliances and Service.

Compared with gas cookers in this country, those of Canada and the United States are finished more attractively, and are smarter and more pleasing in general ap-

pearance. Made of pressed steel and finished in vitreous enamels, there is an infinite variety of colour and design, to suit all tastes. Due to the lightness of construction, they depreciate a little more rapidly than do the cast-iron cookers in this country, which our American cousins refer to as " safes."

It will be recalled by some of the older members present that, about 30 years ago, the late E. W. T. Richmond, of the Richmond Gas Stove and Meter Company, on returning from America, endeavoured to introduce a stamped-steel gas cooking stove, suitable for prepayment consumers. Although the price at which this cooker was offered was extremely low, the venture was not a success. It is much to be regretted that this idea did not mature, as the introduction of such a cooker into this country must at a very early date take place. The capital cost of present-day cookers is much too high, and the production of a cheaper one made in pressed steel and finished in enamel is inevitable if we are to meet competition successfully.

One special feature in American cookers is the placing of a pilot light amongst the boiling and grilling burners, and the pressure of a finger on a spring tap produces four or five long jets which ignite the gas at any burner, the tap of which is turned on. It is interesting to observe that there are 405,000 cookers in use in Philadelphia, as compared with a total of 440,000 consumers, which is a striking example of the popularity of gas cooking in the United States.

In the installation of gas appliances for central heating considerable progress is being made, and a burner, with accessories complete, is available for the conversion to gas of solid fuel appliances. Most companies have introduced special rates for central heating, and this is a question of particular interest in the case of the Author's Company at Portsmouth, where difficulty is found in arranging special terms for this load, which is entirely a winter one.

The substantial consumption of gas obtained in Canada and the United States by the use of gas for water heating is demonstrated by the following figures. Montreal, for example, is installing water heaters of the coil and storage type at the rate of over 8,000 per annum, whilst, in Philadelphia, there are 240,000 in use. The " geyser " type of water heater is now practically non-existent. It was particularly interesting to hear of the success of both countries in obtaining so substantial a load for water heating because such a load will be the principal means of future development for gas in this country, so far as domestic consumption is concerned.

In manufacturing cities, such as Pittsburg, the industrial use of gas has been developed to a very great extent, so much so that, as the Sales Plan, Chart 1, shews, a separate department, under an industrial specialist, is the normal arrangement. It is suggested that with specially low rates for bulk supplies, and with intensive sales propaganda and service work, the use of gas by manufacturers in Great Britain could be considerably increased.

Both in Canada and in the United States, it is strongly felt by those responsible that " service " rendered to the consumer cannot be overdone; in fact, most of the installation work is performed or commenced the same day as the appliance is purchased, or at latest on the following day. Complaints are welcomed and receive the most careful attention, being utilized as a means of improving customer relations. Adjustments and repairs to appliances are also carried out expeditiously, and in many cities all appliances are regularly inspected four times per annum by fitters who go round the district in half-ton motor vehicles. In the case of large consumers, these inspections take place as frequently as once a week.

A large proportion of the work of selling and installing gas burning equipment, which, in Great Britain, is performed by the Gas Companies, is undertaken by plumbers and gas fitters employed by private traders. It is estimated that less than one-half of the appliances sold is handled by the undertakings, the remainder being sold and fitted by dealers. This practice has the support of the American Gas Association, and the arrangement of work is greatly assisted by frequent meetings with a committee of the Plumbers' Association. The importance of this branch of the company's work may be judged from the fact that about 200 gas companies, serving over 7,000,000 consumers, have agreed to the principle of appliances being disposed of and service rendered through dealers and plumbers. By co-operating with dealers in this way, it will be realized that a strong selling service exists for gas and appliances outside the gas undertakings themselves, and it is felt that in this direction much more could be accomplished by undertakings here.

Telephone Order Receiving Table. Brooklyn Union Gas Company.

In the larger undertakings visited, elaborate telephone service systems are installed both for departmental and for outside communication. Whilst the system was most impressive, one felt that the capital and operative costs would be prohibitive in this country.

The Laboratory of the American Gas Association serves a most useful purpose, and sets an example that might well be copied by the Industry in Great Britain.

Coke Sales.

Both in Canada and in the United States, coke is used extensively, not only for factory furnace work, but also for central heating and for water heating appliances in the domestic sphere. The New England Coke Company disposes of approximately 1 million tons of coke per annum, and its sales and distribution arrangements are conducted on the most modern lines and are extremely efficient.

As in all modern plants in this country, the coke is cut, graded, and sold in the following sizes:—

Breeze	Through ½ in. screen
Pea	½ in – ¾ in.
Nut	¾ in.–1¼ in.
Stove	1¼ in.–2¼ in.
Egg	2¼ in.–3 in.
Furnace	Over 3 in.

Coke is also used to a considerable extent for steam raising purposes, and it was interesting to learn that in New York, Pittsburg, and other cities steam generated in this manner is distributed through pipes laid in the streets, in the same way as are gas and water. To supply over 2,000 consumers in Detroit, nearly 30 miles of pipeline have been laid in sizes varying from 4 to 20 in. in diameter.

Aspects of Benzole Recovery and Refining

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The Authors have found that if stripping to the extent of 80 per cent. or over is to take place, not less than 100 gallons of gas oil per ton must be circulated through the scrubbers.

The average figures actually obtained on the North Shields benzole plant over the whole of last year are set out as in example in Table I.

TABLE I.—*Oil Stripping Efficiency Figures*, 1933. *North Shields Benzole Plant.*

Oil circulation	115 galls. per ton of coal carbonized
Average temperature of oil entering scrubbers	24° C.
Average spirit in gas—	
(*a*) Inlet benzole scrubbers	2·74 galls. per ton of coal carbonized
(*b*) Outlet ,, ,,	0·28 ,, ,, ,, ,, ,,
Percentage of spirit recovered	89·8

It may be of interest to note that the spirit remaining in the gas subsequent to oil washing consists of benzene, toluene, and solvent naphtha in almost exactly the same proportions as in the unwashed gas; that is, approximately 10 per cent. of the total of each constituent escapes extraction.

It is sometimes held that gas oil is at a disadvantage compared with coal tar oils such as creosote, in that it is more liable to form sludges and emulsions which tend to be deposited upon the heater tubes and in the coolers, but the Authors' experience has been the exact reverse of this.

Creosote oil, moreover, appears to thicken in use at a much more rapid rate than does gas oil and requires renewal at more frequent intervals.

With a view to ascertaining the effect of prolonged circulation of gas oil upon the nature of the oil itself and also upon its absorptive property towards benzole vapour, it was decided to work the North Shields benzole plant for a year without the removal of any spent oil and to add in the meanwhile only sufficient fresh oil to compensate for wastage and to maintain the stock in circulation at an approximately constant figure. The results of this experiment are embodied in Table II.

These figures shew that prolonged circulation of gas oil denuded of the bulk of the lower boiling fractions has little effect upon the quantity of benzole recovered from the gas, the lower gallonage per ton of coal carbonized obtained at the termination of the test period being almost entirely due to the elimination of constituents derived from the wash oil.

Periodically the wash oil tanks were sludged, but virtually no solid matter or emulsion was noticed, though it may be mentioned that appreciable volumes of water were run off each day from the rotary naphthalene washer which is placed immediately after the benzole scrubbers

TABLE II.—*Effect of Prolonged Circulation (one year) upon the Properties of Gas Oil.*

—	(A). Fresh Oil.	(B). Oil after Circulating One Year.	
1	2	3	
Colour	Pale amber	Dark brown	
Specific gravity at 15·5° C.	0·8 5 0	0·850	
Viscosity (Redwood) at 20° C. (secs)	42	51	
Distillation test—			
Drop point	170° C.	130° C. (Trace of benzole present)	
Below 200° C.	Trace	Trace	
,, 240° C.	2·0 per cent.	1·0 per cent.	
,, 280° C.	37·0 ,,	2·5 ,,	
,, 300° C.	65·0 ,,	17·0 ,,	
,, 320° C.	85·0 ,,	58·0 ,,	
,, 340° C.	..	82·0 ,,	
,, 350° C.	..	86·0 ,,	
		Galls per Ton of Coal.	Retort Test at 120° C.
Benzole produced during first month of test		2·72	74
,, ,, ,, last ,, ,,		2·51	82
Wash oil added to compensate for wastage		0·135 gallon per gallon of crude benzole made	

and is filled with fresh gas oil. The water was, however, quite clear and shewed no trace of emulsion.

The condition of the oil coolers at the end of the year was also investigated by shutting off one section of these, draining out the oil, and removing the flanged bends at the ends. The interiors of the tubes were completely free from pitchy deposits and the original surface of the metal remained visible. These facts are of some importance to undertakings which manufacture straight coal gas in horizontal retorts and, in the absence of a carburetted water gas plant, utilize a proportion of producer gas, together with benzole recovery, as a means of reducing the calorific value to the declared figure.

In these cases, and also in cases where benzole extraction is practised in conjunction with continuous vertical retorts, the only ready means of disposal of the spent oil is the tar well and the addition of large volumes of a paraffinoid mixture to the tar is inadmissible, for in addition to the depreciation in value to the distiller, there is a tendency for insoluble pitch oils to separate out. Hence the less spent oil produced the better, if no water gas plant is available.

The presence of tar fog appears to the Authors to be the most potent factor making for the deterioration of gas oil when employed for benzole washing, and one is inclined to ask whether the modern practice of adding a proportion of "cracked" residues to the oil by the distillers has any bearing upon the problem. Such an oil, containing from 20 per cent. to 25 per cent. of aromatic and unsaturated hydrocarbons, is much more likely to thicken through polymerization and oxidation of these constituents than is a straight run oil consisting in the main of open chain compounds of a paraffinoid nature.

EFFECT OF BENZOLE RECOVERY ON GAS QUALITY.

At the North Shields station the coal gas is generated in semi-silica horizontal settings; the coal is carbonized for a period of twelve hours, and the average of the combustion chamber temperatures is 1330° C. Charging is effected by a De Brouwer type of machine.

The straight coal gas is, in the first instance, diluted to approximately 530 B.Th.U. by the addition of a proportion of producer gas drawn from the settings, and the final reduction to the declared value of 500 B.Th.U. is effected by the extraction of the bulk of the benzole hydrocarbons, the benzole scrubbers being situated between the oxide purifiers and the holder.

The gas is treated in three tower scrubbers with gas oil in quantity equivalent to from 110 to 120 gallons per ton of coal carbonized and the resulting reduction in calorific value averages 27 B.Th.U. per cu.ft. The temperature of the oil varies from 22° C. to 28° C. (depending upon the time of year and the rate of circulation), and since these figures are usually 4° C. or 5° C. higher than the

temperature of the gas, difficulties in working due to water condensed from the latter are not likely to arise. In fact it would be advantageous if the oil were somewhat cooler.

The efficiency of benzole extraction is of the order of 89 per cent., and the average composition of the spirit present in the unwashed gas is given in Table III.

TABLE III.—*Average Composition of Spirit Present in Coal Gas, North Shields Works*, 1933.

—	Per Cent. by Volume.
1	2
Carbon disulphide	0·5
Benzene	60·9
Toluene	17·2
Xylene to 135° C.	3·4
Paraffins	3·1
Residue above 135° C.	4·9
Loss in acid washing	10·0

The average reduction in calorific value (27 B.Th.U.) is due to the removal of 1·9 gallons of spirit per 10,000 cu.ft. of gas, or 2·46 gallons per ton of coal carbonized.

The total volume of crude benzole recovered during 1933 was 77,644 gallons, which includes, of course, a proportion of oil derived from the wash oil.

From the results of a large number of analyses and also from a consideration of the oil wastage figure, it was concluded that 11·6 per cent. by volume of the crude benzole consisted of wash oil or of products derived from the "cracking" of wash oil; in other words, 68,624 gallons of the 77,644 gallons of crude benzole recovered had actually been washed out of the gas.

The total number of therms abstracted from the gas during the year was 102,000, from which it follows that the figure of 1·48 represents the number of therms per gallon of benzole to be credited to the retort house as equivalent to the amount of benzole recovered from the gas.

NAPHTHALENE REMOVAL.

It has been found that whilst it is possible to extract the bulk of the naphthalene from the gas during the process of scrubbing for benzole, complete elimination of this compound is never effected owing to the relatively high temperature of the oil (22° C.-28° C.), and it is necessary to remove the residual 1·6 to 2·0 grains per 100 cu.ft. by treatment with fresh gas oil in a separate rotary scrubber. The spent oil from the latter—approximately 30 gallons per million cu.ft. of gas—is added to the wash oil system of the benzole plant to compensate for wastage. In this way a gas perfectly free from naphthalene vapour is distributed throughout the year.

The naphthalene removed from the gas is almost completely recovered at the debenzolizing still in the wash oil residues refluxed from the dephlegmator. These contain about 7 per cent. of naphthalene by weight and yield only 5 per cent. by volume of solvent naphtha. By bulk they represent 6·1 per cent. of the crude benzole produced, and may either be returned to the wash oil or (as is the case at North Shields) run into a separate storage tank and a proportion added to each consignment of benzole despatched.

It has been noted that the efficiency of naphthalene recovery does not depend upon the length of time the oil remains in circulation, and the amount extracted per 100 cu.ft. is approximately the same whether the wash oil employed is fresh or has been in use for several months and consists principally of constituents distilling above 300° C.

SULPHUR REMOVAL.

One of the most beneficial results attendant upon benzole recovery is the reduction in sulphur content of the gas which takes place due to the extraction from the gas by wash oil of a portion of the carbon disulphide, thiophene, and mercaptans. Prior to the commencement of the process at North Shields the sulphur present in the purified coal gas averaged 22 grains per 100 cu.ft., but oil washing immediately brought about a reduction to 12 grains. In Table IV. the average reduction obtained during 1933 is shewn together with the carbon disulphide content of the crude benzole made over the same period.

TABLE IV.—*Sulphur in Purified Gas, North Shields Works*, 1933.

Inlet benzole scrubbers	. .	22·0 grains per 100 cu.ft. (Referee's test).			
Outlet ,, ,,	. .	11·9	,,	,,	,, ,,
Reduction	. .	10·1	,,	,,	,, ,,

Average carbon disulphide content of crude benzole, 1933—0·37 per cent. by volume equivalent to 5·8 grains of sulphur per 100 cu.ft. of gas.

Hollings and Hay[1] state that in the oil washing process for benzole recovery the maximum overall reduction in sulphur content of the gas at an oil-gas ratio of 8 gallons per 1,000 cu.ft. is about 40 per cent., of which half represents the complete absorption of the thiophene group and the remaining half one quarter of the carbon disulphide.

The reduction in the sulphur at North Shields is of the order of 45 per cent., or 10·1 grains per 100 cu.ft., with an oil-gas ratio of 9 gallons per 1,000 cu.ft., of which figure carbon disulphide recovered in the crude benzole accounts for 5·8 grains; the more or less complete extraction of thiophene together with a small quantity of mercaptans is responsible for the remaining 4·3 grains.

These figures agree broadly with those deduced by Hollings and Hay for a similar oil-gas ratio, and the value of a benzole oil washing process for removing volatile sulphur-containing compounds from the gas will at once become apparent.

It would seem that the extraction of the remaining 60 per cent. of sulphur, present almost entirely in the form of carbon disulphide, might be conveniently carried out in some form of active carbon filter seeing that the gas to be treated would contain little benzole vapour and no naphthalene.

If some such adsorbent could economically be adopted a sulphur-free gas would result, the advantages of which to the Gas Industry it is unnecessary to emphasize.

It must be appreciated, however, that reductions in sulphur content to the extent of 40 per cent. can only be looked for when the volume of wash oil employed is sufficient to recover up to 90 per cent. of the benzole hydrocarbons. If it is desired to extract a portion only of these then a corresponding decrease in the quantity of sulphur bearing compounds removed from the gas will take place.

At the same time partial stripping implying a low oil-gas ratio has the effect of leaving benzene in the gas so that the crude benzole recovered will show a higher proportion of toluene, xylenes, paraffins, and unsaturated hydrocarbons. This is shown in Table V., where the compositions of crude benzole produced at oil-gas ratios of 6 and 9 gallons per 1,000 cu.ft. are set out for comparison purposes.

TABLE V.—*Effect of Variation in Oil-Gas Ratio upon Crude Benzole Composition.*

—	Sample A.	Sample B.
1	2	3
Oil-gas ratio per 1,000 cu.ft.	9	6
Specific gravity	0·868	0·867
Retort test (percentage distilling at 120° C.)	83	80
Loss in acid washing	8·5 per cent.	10·0 per cent.
Acid washed benzole	63·4 ,,	57·5 ,,
Benzene		
Toluene	14·8 ,,	16·5 ,,
Xylene to 135° C.	2·2 ,,	4·5 ,,
Paraffins	4·6 ,,	4·8 ,,
Fraction 135° C.–190° C. (Higher benzene homologues)	1·6 ,,	3·4 ,,
Residue and loss	13·4 ,,	13·3 ,,
Gallons per ton of coal carbonized	2·5	2·1

The presence of paraffins in crude benzole is not desirable whilst abnormally high proportions of unsaturated hydrocarbons spell heavy loss when the benzole is washed with sulphuric acid, though with the introduction of the inhibitor process this is not of such moment except that

[1] Hollings and Hay; "The Recovery of Benzole by Active Carbon," Journ. Soc. Chem. Ind., 1934, 53, No. 7, pp. 143-155.

the heavier unsaturated hydrocarbons present difficulties in inhibition, and a partial treatment with acid is sometimes necessary.

DEBENZOLIZING PLANT.

The annual output of gas at the North Shields station being in the neighbourhood of 380,000,000 cu.ft., the debenzolizing plant is designed to produce from 250 to 270 gallons of benzole per day, yielding 82 per cent. at 120° C., when distilled in a side-armed flask. It is of a compact modern type erected in the open upon the roof of the pump and control house.

Whilst it would not be strictly correct to state that the plant is entirely automatic in action, labour charges are practically negligible. Supervision, which is carried out by the exhauster-engineman as part of his regular duties, includes only the occasional regulation of the oil pumps, the checking of steam pressures, and the periodical reading and logging of thermometer records. An hour and a half per day would be a generous allowance under this head.

The steam consumption has worked out somewhat higher than was expected. Hollings and Hay[2] instance 41 lbs. per gallon as the best steam consumption noted in connection with the oil recovery process, under conditions of working such that 88 per cent. of the benzole in the gas was being extracted. At North Shields, however, with an oil circulation of 9 gallons per 1,000 cu.ft. the average steam consumption during 1933 reached 64 lbs. per gallon of benzole. Of this total 31 lbs. represented steam supplied to the still and 33 lbs. steam supplied to the oil preheater. The pumps accounted for a further quantity of steam equivalent to 10·9 lbs. per gallon of benzole so that the average total steam consumption on the plant for the year was as much as 74·9 lbs. per gallon of crude benzole produced.

Attempts were made to utilize the exhaust steam from the oil pumps by turning this into the debenzolizing still, but, as might have been expected, the experiment proved unsuccessful, seeing that the steam was wet and entered the still at a temperature considerably lower than that of the incoming oil from the preheater. The daily make of benzole, in consequence, fell off by about 20 per cent., only a portion of the toluene, solvent naphtha, and naphthalene were recovered, whilst water commenced to accumulate in the wash oil. Consequently reversion to the employment of live steam became necessary.

Lower figures for steam consumption could have been obtained by the adoption of a more comprehensive oil to oil heat exchange system. Under existing circumstances the cold benzolized oil is merely circulated through the benzole dephlegmator containing comparatively cool vapour before entering the preheater proper, in which indirect steam at 25 lbs. pressure is employed to raise the temperature to 120° C. On the other hand, the hot debenzolized oil at a temperature of 105° C. is led directly from the still to the water coolers, and the sensible heat is in consequence largely wasted.

The fact must not, however, be overlooked that the provision of an oil-to-oil heat exchanger on the debenzolized oil line from the crude still may not be advisable if the tubes are likely to become obstructed with solid matter deposited from the oil, and any saving in steam is likely to be offset by irregular and unsatisfactory working of the crude still.

Economy in steam consumption could also have been realized by circulating the wash oil through the scrubber at a slower rate, with the resulting imperfect extraction of benzene from the gas; and again the saving in steam would not compensate for the loss of revenue from this source.

The water coolers provided for the debenzolized oil have not proved quite satisfactory, and in no instance—even in the coldest weather—has the temperature of this oil been reduced to below 20° C. at the scrubber inlet. It is advisable, of course, that the oil should be slightly warmer than the gas, but the difference need not exceed 2° C., and certainly should not amount to as much as 8° C. or 10° C., as was frequently the case at North Shields during the summer.

Moreover, if oil cooling were more completely under control, smaller volumes of wash oil would be required for a given scrubbing efficiency resulting again in a lower steam consumption on the plant. The Authors' experience with different types of benzole plant, both with and without oil to oil preheaters, points to the conclusion that the provision of these does not solve the oil cooling problem which is well-worth careful consideration.

The actual distillation of the benzole from the benzolized oil in the crude still presented no difficulty, and little comment is necessary upon this phase of the operations.

COST OF BENZOLE EXTRACTION.

In Table VI. the operating costs of the North Shields benzole plant for the whole of 1933 are shewn:—

TABLE VI.—*Benzole Plant. Operating Costs*, 1933.

—	Per Gall.
1	2
Average price received for crude benzole . . .	11d.
Steam—17,400 lbs. per day at 1s. per 1,000 lbs. .	0·98d.
Labour (including loading and unloading tank wagons, supervision, and lubricants)	0·29d.
Water	0·18d.
Oil wastage—11,535 galls. at 4d. per gall. . . .	0·59d.
Net cost of extra coal carbonized	1·28d.
Purification of extra gas made	0·06d.
Interest and depreciation on plant at 10 per cent. } Allowance for repairs—2½ per cent. . . . . }	0·58d.
Total operating costs	3·96d.
Excess of receipts over expenditure	7·04d.

Since the thermal content per gallon of spirit actually derived from the gas is 1·48 the price realized per therm of benzole vapour extracted is 7·4d.

It is to be noted that, in the above table, the whole of the cost of the wash-oil wastage is charged against the benzole recovery process, and no allowance is made for naphthalene extraction.

It can, of course, be argued that naphthalene removal is incidental upon benzole washing, and that in consequence the latter should be credited with a portion of the cost. Alternatively, there is the view that the benzole scrubbers are expected to remove the naphthalene down to a suitable limit, and if they fail to do so the whole cost of any extra washing incurred should be added as an extra cost involved by the inefficient performance of the benzole plant.

No attempt has been made to assess in terms of money the savings brought about by the reduction of sulphur in the gas, but this benefit should not be forgotten.

The low cost of water is due to the fact that the cooling water is recirculated and charges for pumping only are incurred.

Prior to the inauguration of benzole extraction, the whole of the coal gas was produced in nine horizontal settings, but when oil washing commenced it became necessary to bring into commission an extra oven to compensate for the heat units removed by the process.

No additional labour charges were incurred in the retort house, as the same number of men were required to deal with ten settings as with nine. If, however, as the result of benzole washing, the larger volume of gas requiring to be manufactured necessitated an addition to the retort house staff, then this charge would need to be taken into consideration in addition to the allowance made for increased wear and tear attendant upon the bringing into commission of the extra setting.

The figures quoted, the Authors believe, are typical of what may be obtained on any undertaking of moderate capacity under ordinary conditions of working, and, it is held, are such as fully to justify the adoption of the process.

CRUDE BENZOLE.

As an illustration of the changes which have taken place in carbonizing technique since the war, Table VII. has been prepared.

Here the specific gravities of rectified benzole and

[2] Hollings and Hay; "The Recovery of Benzole by Active Carbon," Journ. Soc. Chem. Ind., 1934, 53, No. 7, pp. 143-155.

toluole produced by the Newcastle-upon-Tyne and Gateshead Gas Company during the war and at the present time are compared.

TABLE VII.—*Specific Gravity—Rectified Benzole and Toluole, 1917 and 1933.*

—	Specific Gravity.	
	1917.	1933.
1	2	3
Rectified benzole (95 per cent. at 90° C.)	0·883	0·876
,, toluole (90 ,, at 120° C.)	0·869	0·864

The lower density of the present day products is due to the presence of from 4 per cent. to 6 per cent. by volume of paraffins which are produced as the result of the modern practice of feeding much heavier coal charges into horizontal retorts.

Heavy charges reduce the proportion of free space above the coal and allow more paraffinoid and unsaturated hydrocarbons to escape thermal degradation. They are washed out of the gas simultaneously with the aromatic hydrocarbons and eventually appear in the crude benzole.

The ultimate effect of the size of coal charge upon the specific gravity, sulphur content, and paraffin content of the benzoles produced upon three manufacturing stations of the Newcastle and Gateshead Gas Undertaking is given in Table VIII.

It will be observed that higher combustion chamber temperatures are necessary to carbonize completely the heavier charges worked at Station C, but temperature effect has less influence in bringing about degradation of the primary and paraffinoid distillation products than has the prolongation of the time of exposure of these constituents to the heated surface of the retorts.

The large difference in the paraffin contents of the benzoles produced on Stations A and B may appear at first sight anomalous seeing that the proportion of retort space occupied by the charges and also the combustion chamber temperatures are practically the same. The reason is to be found in the even heating which is possible in the case of the settings installed at Station A, in consequence of

TABLE VIII.—*Effect of Weight of Coal Charge upon Benzole Quality.*

—	Station A.	Station B.	Station C.
1	2	3	4
Type of retort	Horizontal	Horizontal	Horizontal
Sectional area of retorts (inches)	24 in. × 18 in.	22 in. × 16 in.	22 in. × 16 in.
Number of retorts in setting	10	8	8
Combustion chamber temperature (° C.)	1,340	1,320	1,400
Carbonizing time (hours)	12	12	12
Coal per cubic foot of retort space	31·9	32·0	37·8
Retort test of crude benzole (per cent. at 120° C.)	67·0	79·0	78·5
Paraffin content of crude benzole (per cent.)	1·5	4·6	6·3
Sulphur content of crude benzole (per cent. by weight)	0·8	0·65	0·60
Loss in acid washing (5 per cent. of 95 per cent. H_2SO_4)	4·0	8·0	6·0
Specific gravity of refined benzole	0·873	0·868	0·866

which the degree of thermal degradation suffered by the products of distillation is more or less the same in each retort.

At Station B the retorts are arranged in settings of eight disposed in three tiers. Even heating is a difficult proposition, and the bottom retorts are frequently 200° C. cooler than those at the centre. Consequently, whilst the paraffin content of the gas from the latter may be the same as or even less than that of the gas derived from the retorts at Station A, there will be a proportion evolved from the bottom retorts which has been subjected to much less drastic conditions and which will contain a sufficiently high proportion of paraffins to influence the composition of the resulting crude benzole in the manner shown in Table VIII.

In the case of continuous vertical retorts, figures have been published[3] showing the specific gravity of the crude benzole produced to be as low as 0·830. This is to be expected, for though little more light oil per ton of coal carbonized is obtained from vertical retorts than from well filled horizontals, the oil is of a decidedly paraffinoid nature, whilst washing with sulphuric acid results in a volume loss of 20 per cent. or more.

A further point which suggests itself is to what extent benzole recovered from coal gas by means of gas oil is likely to become contaminated by low-boiling distillates —paraffins and unsaturated hydrocarbons—derived from the " cracking " of the constituents of the oil.

Gas oil produced from American petroleum consists of a mixture of paraffins, unsaturated hydrocarbons, aromatic compounds and naphthenes in varying proportions, the average composition of that employed by the Newcastle and Gateshead Gas Company being:—

	Per Cent.
Paraffins	55
Olefines	7
Aromatics	20
Naphthenes	18

Such a mixture distils almost completely between 230° C. and 380° C., so that unless " cracking " of the constituents takes place to an appreciable degree the probability is that the volume of paraffins and unsaturateds present in motor spirit is not likely to be increased by the employment of gas oil.

Attempts have been made to ascertain the extent to which " cracked " products are present in the lower boiling portions of the crude benzole by comparing the composition of the spirit washed from coal gas by cresylic acid with the composition of a corresponding fraction of crude benzole recovered at the same time by gas oil on the benzole plant. In Table IX. figures representing the average of a number of such tests are given.

It would seem from a consideration of these results that it is probable a slight decomposition of the wash oil does actually take place, and in consequence the paraffin content of the refined benzole is increased by from 1 per cent. to 1·5 per cent., though it is clear that changed conditions of carbonization and not the substitution of gas oil for creosote in the benzole scrubbers account for the larger proportions of paraffins found in present-day motor spirit.

TABLE IX.—*Composition of Spirit (0° C.–135° C.) washed from Coal Gas by Cresylic Acid and Gas Oil.*

—	(A). Cresylic Acid.	(B). Gas Oil.
1	2	3
	Per Cent.	Per Cent.
Loss in acid washing	7·7	10·0
Composition of washed residue—		
Benzene	72·3	71·2
Toluene	20·7	18·2
Xylenes	1·9	3·9
Paraffins	4·3	6·3
Carbon disulphide	0·8	0·4
Gallons per ton of coal	2·01	2·03

As shown in Table VIII. differences in carbonizing conditions bring about variations in the quality of benzole, particularly as regards the content of paraffin, sulphur, and unsaturated hydrocarbons, the last being indicated by the loss in acid washing. All of these may affect the value of the benzole. None of these crudes, refined separately by the acid wash process will yield motor benzole complying fully with the specification of the National Benzole Association, those from Stations B and C being too low in specific gravity whilst benzole from Station A is too high in sulphur. When worked together, however, the resulting motor benzole passes the specification in every respect.

Nevertheless, the presence of even a small percentage of paraffin does to some extent affect the value of the benzole, the material being unsuitable, on account of its low specific gravity, for the manufacture of 90's benzole,

[3] C. H. Chester; " Recovery of Benzole from Vertical Retort Gas," Gas Journal, 1934, **205**, pp. 551-555.

90's toluole and other products to the Standard National Benzole Association Specifications.

The paraffins occur throughout the range of distillation, the proportion increasing in the higher boiling fractions. They cannot be avoided by close fractionating; thus a " pure " toluole boiling within 0·4° C. still contained 5 per cent. of paraffins.

As reported by previous observers, sulphur content varies inversely as the paraffins. The average sulphur content, however, is not excessive, and in refining by the acid wash process, gives no trouble. Adoption of the inhibitor process, as will be seen later, makes necessary the removal of sulphur compounds and a high sulphur content becomes of some moment.

The higher proportion of unsaturated hydrocarbon in benzole from Stations B and C, as indicated by the loss in acid washing, is of interest inasmuch as a greater saving is obtained in the application of the inhibitor process to these benzoles.

BENZOLE REFINING BY THE ACID WASHING PROCESS.

In the acid washing process formerly used at the By-product Works of the Newcastle-upon-Tyne and Gateshead Gas Company, the crude benzole was washed as received, the customary " once-running " distillation being omitted. Long experience has shewn that no serious disadvantage arises from this procedure. Fewer stills and receivers are required, and there is appreciable economy in labour, steam, and distillation losses.

It is an advantage to add the strong acid in more than one wash, as thereby a smaller quantity of acid is required to produce benzole of the correct acid wash test. This is to be expected, for the products of the earlier washes are removed and more effect is then obtained with succeeding washes. There also appears to be less risk of pitchy matter being left in the washer.

It has been stated[4] that both of the above mentioned expedients may tend to leave neutral sulphuric esters in the benzole, which on distillation may decompose with liberation of sulphur and sulphur dioxide, contaminating the benzole and causing undue corrosion. This possibility is admitted, but in the Authors' experience, no instance of acidity or of free sulphur in the benzole has been observed over a number of years. Corrosion of the plant has occurred, but mainly in parts which can be renewed at little inconvenience and expense.

The saving is substantial and probably exceeds by far any cost incurred through such corrosion.

The washing given was with $1\frac{1}{4}$ per cent. B.O.V. (2 hours), $1\frac{1}{4}$ per cent. R.O.V. (2 hours), two water washes and alkali wash (4 hours), total time 8 hours, not including charging and discharging the washer. The loss due to washing was about 4 per cent., but it should be noted that the loss of motor benzole is not wholly represented by the amount lost in the washer. Certain unsaturated hydrocarbons are polymerized, and form part of the residue on distillation.

The rectifying still is fitted with a fractionating column of the ring packed type, and as the efficiency of this column has some bearing on the separation of carbon disulphide referred to later in this paper some account of its construction and performance is given below.

The column consists of a steel cylinder, 24 ft. by 2 ft. 8 in. diameter, lagged to prevent loss of heat and packed with $1\frac{1}{2}$ in. Lessing rings of stoneware. The continuity of the packing is broken by grids at one-third and two-thirds of the height, a space of 2 in. being left between the bottom of each grid and the mass of packing just below it. This reduces any tendency to " channelling." Working without any reflux and depending for irrigation of the packing upon the liquid which may condense in the column, a satisfactory yield of motor benzole can be obtained directly from the washed crude benzole at an average rate of 150 gallons per hour.

When closer fractionation is required, a controlled proportion of the condensed distillate is returned, by means of a small pump, to the top of the column.

The efficiency of fractionation may be judged by the yield and quality of fractions obtained in one distillation from washed crude benzole. Using a refluxing ratio of 1·5 to 1·0 and collecting at 80 gallons per hour, the fractions obtained, no intermediates being separated, tested as follows:—

Fraction.	Per Cent of Charge.	Test of Fraction.
Benzole	60	Drop 79° C. $\frac{85° \text{ C.}}{95 \text{ per cent.}}$ (toluene, 4 per cent.)
Toluole	12	Drop 100° C. $\frac{120° \text{ C.}}{93 \text{ per cent.}}$ (toluene, 72 ,,)

Despite the greatest care taken in the final alkali treatment in the washer, some corrosion of the distilling plant occurred. The inside of the still and column were wasted about $\frac{1}{16}$ in. after nine years' working. The condenser coil of wrought iron lasted about five years. The packing of the column which formerly consisted of iron rings suffered most, and was badly corroded in three years.

BENZOLE REFINING BY THE INHIBITOR PROCESS.

The inhibitor process for refining motor benzole has largely displaced the acid washing process throughout the country, and is already so well known that description is unnecessary. There is now briefly discussed the application of the process in the By-products Works of the Newcastle-upon-Tyne and Gateshead Gas Company. The advantage gained is recorded, and mention is made of some aspects which may be of interest.

Preliminary examination showed that if acid washing were omitted entirely, the benzole distilling over was, in the later fractions, yellow in colour, and of indifferent odour.

A wash with 5 per cent. of 10 per cent. solution of caustic soda, followed by a wash with 0·75 per cent. by volume of B.O.V. (77 per cent. H_2SO_4) previously diluted with twice its bulk of water was sufficient to correct this.

Using undiluted B.O.V. a small quantity of acid tar was formed, which gave trouble in a subsequent treatment for removal of sulphur.

The washed crude benzole, distilled over a 12 bulb Young column to a temperature of 160° C., gave a high yield of benzole of the correct distilling range (final point 95 per cent. at 145° C.), which, however, on inhibiting with 0·03 per cent. of cresol, gave too high an oxidation test.

A more stable benzole could be obtained by eliminating a small amount of the " heavy end " or by a modified wash with strong acid of either the whole or the heavier part of the benzole. A diminished yield resulted in each case. In order to avoid this loss, more potent inhibitors were tried. The addition of 0·01 per cent. of alpha naphthol gave a satisfactory gum test, whilst a mixture of 0·03 per cent. cresol and 0·005 per cent. alpha naphthol was not only cheaper but still further improved the gum test.

The oxidation tests were:—

Benzole to 160° C.	without treatment				254	mg. of gum per 100 c.c.
,,	,,	+ 0·03	per cent.	cresol	25	,,	,,
,,	,,	+ 0·01	per cent.	alpha naphthol	4	,,	,,
,,	,,	+ 0·03 & 0·005	per cent. per cent.	cresol alpha naphthol	3	,,	,,
,,	155° C.	0·03	per cent.	cresol	10	,,	,,

It is concluded from these results that (1) the higher boiling unsaturateds are the less amenable to inhibition by cresol, and (2) some advantage may be obtained by the use of mixed inhibitors.

Applying the process on the works, inhibition by cresol alone gave better results than had been obtained in the laboratory. The explanation of this is believed to be that in a flask distillation local overheating produces changes in the benzole which do not occur in works practice. Nevertheless, to obtain the maximum yield of benzole of the correct gum test, an inhibitor more powerful than cresol must be used.

The use of alpha naphthol proved to be undesirable, the

[4] National Benzole Association, Report of the Research Committee, 1929, p. 147.

benzole turning yellow on exposure to daylight. Samples of benzole inhibited by alpha naphthol remained of good colour after 12 months' storage in the dark, but on exposure to daylight became quite yellow in a few days.

Catechol, a very effective inhibitor, does not affect the colour of the benzole, and is now used in admixture with cresol.

Advantages of the Inhibitor Process.

By the inhibitor process, there is an increased yield of motor benzole of about 5 per cent. The cost of acid for washing is reduced by 80 per cent., but this is in part counterbalanced by the cost of special treatment necessary to remove excess sulphur.

There is no troublesome acid tar to handle, and the waste acid is clean enough to use for other purposes, in this instance for the extraction of pyridine from light tar oils. It is believed that corrosion of the distilling plant will be considerably reduced. The increased yield and saving in acid are not as high as have been reported by some refiners, no doubt because the acid washing displaced was not very drastic; the saving reported, however, is substantial.

REMOVAL OF CARBON DISULPHIDE.

On turning over to the inhibitor process, the problem of sulphur content became acute. Thiophene and similar sulphur compounds now remained in the benzole, and the total sulphur content was much too high. There is no known practicable means of removing thiophene without at the same time destroying the unsaturated hydrocarbons. Attention was therefore directed to removal of part of the carbon disulphide. The benzole contained about 0·65 per cent. total sulphur, so that it was necessary to remove 0·25 per cent.

(*a*) Removal by Fractionation.

Removal of even so small a quantity as 0·25 per cent. by distillation in the plant described previously, could only be done by very slow fractionation.

Some 10 per cent. of forerunnings required to be taken off, causing delay in the working of the still and necessitating storage for the fractions. The forerunnings could be concentrated by redistillation, but there remained the difficulty of disposing of the final carbon disulphide fraction.

Separation by distillation is more difficult than in the case of acid washed benzole. This has been investigated, and the following samples prepared:—

(1) Forerunnings from still containing 3·7 per cent. CS_2 (by volume).
(2) Forerunnings with CS_2 extracted by treating with alcoholic soda.
(3) Forerunnings with unsaturateds removed by acid washing (loss 28 per cent.).
(4) Forerunnings with both CS_2 and unsaturateds removed.
(5) A mixture of pure benzene and pure CS_2 (3·7 per cent. by volume CS_2).

These were fractionated carefully under identical conditions in a column 36 in. by 2 in. packed with $\frac{3}{8}$ in. Lessing rings of copper, a refluxing condenser being used.

The respective distillation ranges are shown in Figure 1. The distribution of CS_2 in the fractions is given in Table X. During the fractionation of samples (1) and (2) uncondensed vapours were observed, and the first distillate came over at 16° C.

It will be seen that unwashed forerunnings contain appreciable quantities of both unsaturateds and paraffins boiling at and below the boiling point of carbon disulphide. It is evident that even with a good fractionating plant the concentration of CS_2 could not be much more than, say, 50 per cent.

Such a product is almost unsaleable, and its production, together with losses by distillation, robs the benzole of material of low boiling point which is valuable, not only as a fuel, but particularly for promoting easy starting and acceleration.

It is probable also that if, in the first distillation of crude benzole, forerunnings are taken off slowly, vapours are lost, which at an ordinary rate of distillation would remain dissolved in the benzole. It was decided therefore that removal of CS_2 by chemical means is desirable, provided the cost is not excessive.

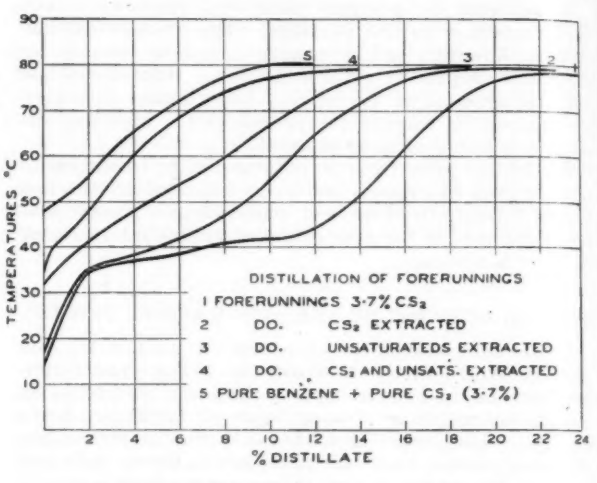
TEMPERATURES °C
% DISTILLATE
DISTILLATION OF FORERUNNINGS
1 FORERUNNINGS 3·7% CS₂
2 DO. CS₂ EXTRACTED
3 DO. UNSATURATEDS EXTRACTED
4 DO. CS₂ AND UNSATS. EXTRACTED
5 PURE BENZENE + PURE CS₂ (3·7%)

FIGURE 1.—*Distillation Ranges of Samples.*

(*b*) The Methanol-Soda Process.

Much valuable work on chemical processes had already been done by the Research Department of the National Benzole Company, Ltd., and this was willingly made available, several processes being suggested, only two of which appeared promising. The first, treatment with sodium sulphide, involved washing the benzole at a temperature of 50° C., which suggested much loss by evaporation and added fire hazard. The second method based upon the use of alcoholic soda at ordinary temperatures seemed more attractive and was investigated.

TABLE X.—*Distribution of CS_2 in Fractions from Forerunnings containing 3·7 Per Cent. CS_2 by Volume. Successive 2 Per Cent. cuts taken. CS_2 expressed as Per Cent. by Volume of each Fraction.*

No. of Fraction.	Untreated Forerunnings.		Forerunnings Unsaturateds Removed.		Pure Benzene + Pure CS_2. (CS_2 equals 3·7 Per Cent. Vol.)	
	Temp. of Fraction.	CS_2 in Fraction.	Temp. of Fraction.	CS_2 in Fraction.	Temp. of Fraction.	CS_2 in Fraction.
1	2	3	4	5	6	7
	° C.	Per Cent. Vol.	° C.	Per Cent. Vol.	° C.	Per Cent. Vol.
1	34·5	6·2	43·5	40·2	55·0	71·8
2	36·5	17·0	52·0	56·2	65·5	52·8
3	38·5	20·0	59·5	51·0	74·0	45·2
4	40·0	21·2	69·0	40 0	79·0	11·3
5	43·0	25·6	76·0	15·0	80·3	2·9
6	46·5	30·0	79·0	4·3	80·3	0·7
7	51·5	20·6	79·5	0·56	80·3	0·3
8	58·0	20·0	80·0	0·34	80·3	*Nil*
9	67·0	11·1	80·0	0·27		
10	72·0	3·5	80·3	*Nil*		
11	77·0	0·9				
12	79·0	0·5				

This, the Methanol-Soda Process, in connection with which patent applications have been filed by the National Benzole Company, Ltd., is based upon the reaction at ordinary temperatures between carbon disulphide, methyl alcohol (methanol), and caustic soda according to the equation

$$CS_2 + NaOH + CH_3.OH = NaS.CS.OCH_3 + H_2O.$$

Sodium methyl xanthate is formed, and on the addition of water dissolves and can be separated completely from the benzole. The operation can be conveniently carried

out in the washer after the usual washes, and may take the place of the final alkali wash. The process provides for recovery of a large proportion of the methanol.

Works Experience.

To a washer charge of 2,500 gallons after carefully draining off the last water wash 25 gallons of methanol and 50 lbs. of "flake" caustic soda are added. After 4 hours' agitation, 50 gallons of water are run in and stirring continued for 30 minutes. The xanthate solution settles readily, and is run off to a receiver. Two washes each with 25 gallons of water are then given, the washings being added to the main xanthate solution in the receiver. The benzole is now ready for the still.

The reduction of sulphur content is 0·25 per cent., which is equivalent to a removal of sulphur of 0·22 grm. per c.c. of methanol, and 1·08 grms. per gram of caustic soda.

This treatment lengthens the time of the washing operation by 6½ hours, but as washer capacity is ample this has not caused difficulty.

Dilution of the Xanthate.

The two small water washes following the xanthate wash are necessary, otherwise much methanol will be lost in the benzole. Also the xanthate solution requires to be diluted in order to get the best results in the recovery process adopted.

If hard water is used, there may be some risk of a precipitate due to the action of caustic soda. Distilled water may conveniently be obtained from the steam traps of the benzole still. If these are of the elevating type, condensed water may be delivered into a tank at the top of the washer.

Precautions.

In connection with treatment in the washer, the following points are to be noted.

If the methanol treatment follows a wash with strong acid, the xanthate solution may be contaminated, and not settle out cleanly. This may occur however carefully the intervening water washes may be given.

In cases where a strong acid wash must of necessity be given this difficulty may be avoided by applying the methanol treatment before the acid wash, or alternatively by separating forerunnings by distillation and subjecting these to methanol treatment. Caustic soda suitable for this process may be obtained in the flake or powder form, both at the same price. The flake quality is recommended if only for the reason that the powder is liable to cake above the washer outlet and cause troublesome stoppages. The methanol used is the "blending" quality. Pure methanol is cheaper, but its use is controlled by excise restrictions which make the saving in cost not worth while.

Recovery of Methanol.

The method adopted for the recovery of methanol is based upon the fact that sodium methyl xanthate is quickly and completely decomposed on treatment with dilute sulphuric acid.

The main products of the reaction are methanol, carbon disulphide, and sodium sulphate. In addition, hydrogen sulphide, sulphur, and small amounts of organic compounds of unknown composition are produced by side reactions. The chemical changes occurring in these side reactions are not yet fully known.

If the solution is sufficiently dilute, and the acid is added slowly with constant mixing, there is but a slight rise of temperature. On standing, crude carbon disulphide containing dissolved sulphur settles out at the bottom as a black layer which separates cleanly, and may be run off. From the remaining liquor, methanol may be obtained by a fractional distillation. This recovered methanol is practically free from sulphur, showing that the separation of carbon disulphide is complete. It has a somewhat unpleasant odour, due to presence of impurities, but appears to be no less effective in use than fresh methanol.

Emission of hydrogen sulphide during neutralization of the xanthate complicates the recovery process. Determination of the amount of hydrogen sulphide liberated in the process gave interesting results:—

Freshly prepared xanthate . .	0·08 grm. H_2S per 100 c.c.
After storing for three months .	0·98 ,, ,, ,, ,, ,,
After storing for six months . .	1·90 grms. ,, ,, ,, ,,

The xanthate slowly decomposes on keeping, and acquires a most unpleasant odour. The residues should therefore be worked up as quickly as possible, especially as there is evidence of some loss of carbon disulphide and possibly of methanol on ageing.

The amount of acid used should be just sufficient to neutralize the caustic soda originally present. This can be determined by titration. A measured 10 cc. of the xanthate is diluted with 50 cc. water, 20 cc. of normal H_2SO_4 added, and the mixture boiled to expel sulphuretted hydrogen. On back titration, with normal alkali, the amount of acid required may be calculated.

Description of the Plant.

The arrangement of the plant is shown in Figure 2. The neutralizer A, capacity 580 gallons, is a replica of the conventional benzole washer, with the exception that the top is gas tight, the shaft revolving in a stuffing box with gland. The inside, including the shaft and paddles and the underside of the top, are completely lined with lead. A bottom outlet for carbon disulphide and a side outlet for methanol liquors are provided.

The top fittings include handhole with lid, dipping cock, manometer gauge, inlet for acid and xanthate liquors, and a pipe to conduct gases to a purifier (oxide heap) at some distance away. A small steam jet fitted into this pipe serves to accelerate the flow and to moisten any deposit of iron sulphide to prevent spontaneous combustion.

Xanthate solution is stored in the tank D, from which it is run in visible feed to the box E connected via a sealpipe to the inlet of the neutralizer. Box E is also used for introducing dilute sulphuric acid.

The Methanol Still.

The methanol still, B, Figure 2, is a steel vessel, capacity 180 gallons, heated by means of a steam coil in the bottom.

The fractionating column is a 12 in. diameter flanged pipe 18 ft. long, packed with 1 in. Lessing rings of stoneware.

Dephlegmating and main condensers are provided, and receivers for strong and weak methanol.

The steam coil has a heating surface of 7·5 sq. ft. The dephlegmating and main condensers have cooling surfaces of 10 sq. ft. and 20 sq. ft. respectively.

Regarding the size of the still, this vessel happened to be available; the capacity might more conveniently have been equal to that of the neutralizer.

Neutralizing the Xanthate Liquors.

The requisite quantity of diluted B.O.V. (1 vol. B.O.V. to 3 vols. water) is put into the neutralizer, and clear settled xanthate solution is run in slowly with agitation, the feed being adjusted so that pressure in the vessel due to evolution of gases does not become excessive. Care must be taken in measuring the liquids, for if too little acid is used, the recovered methanol will be of bad odour.

At the dilutions indicated, there is no rise of temperature, and artificial cooling has not been necessary.

Liquors must be clean and free from entrained benzole, or the carbon disulphide will be contaminated.

Stirring is continued for a few minutes after the correct quantity of xanthate has been added. After settling for an hour, crude carbon disulphide is run off from the bottom.

The liquor is made alkaline by addition of a few lbs. of caustic soda, which absorbs any hydrogen disulphide, and prevents corrosion of the still in the next operation. The same effect is by no means obtained by using less

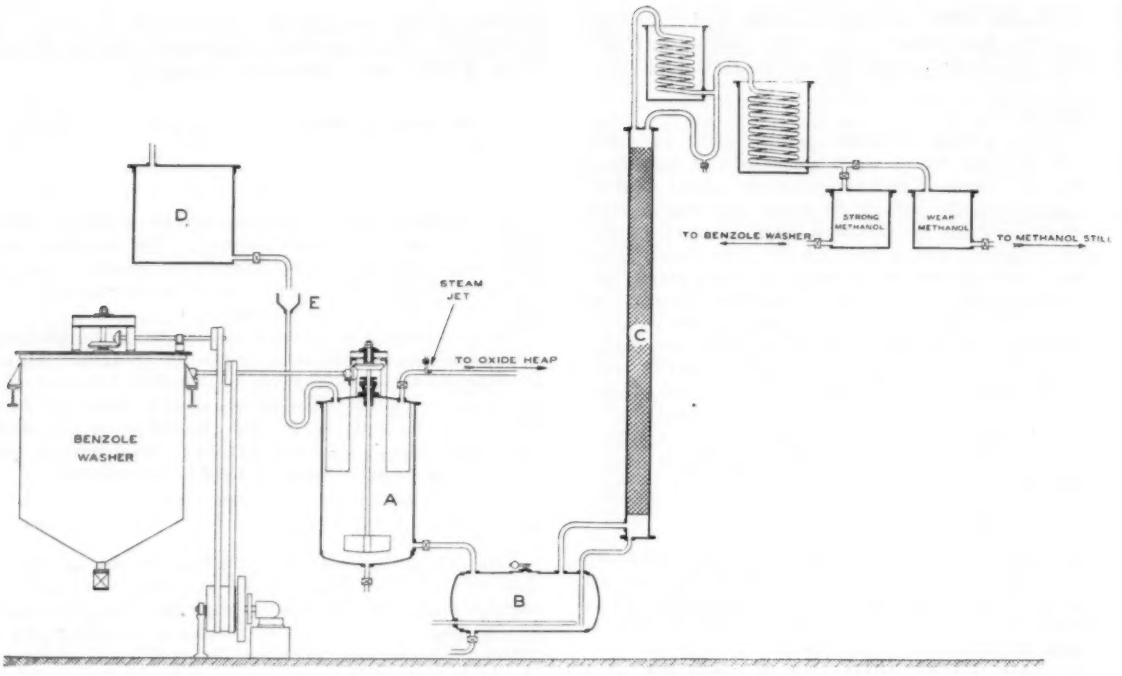

FIGURE 2.—*Plant for the Recovery of Methanol.*

acid in the first instance. A charge can be worked through the neutralizer in six hours.

Fractionating the Methanol.

The liquor which contains about 15 per cent. of methanol is now fractionated. Reflux is used in the column, and in spite of the low methanol content of the charge, separation of high strength methanol is very satisfactory. Collecting at the rate of 6 gallons per hour, methanol of 97 per cent. strength is recovered in one distillation. A second fraction of weak methanol, collected until only water is coming over, amounts to 5 per cent. of the still charge, and is concentrated by redistillation. The fractionating effect of the column is shown in Figure 3, a curve showing the result of working without the reflux also being given. The latent heat of vaporization of methanol being high (262 calories per gram) the amount of condensate forming in the column is small, and the effect of reflux on fractionation is therefore very marked. Control of working is simple, the specific gravity of the distillate referred to gravity tables indicating the methanol content.

Distillation data have been noted as follows:—

Charged to still (15 per cent. methanol)	140 galls.
Strong methanol obtained (97 per cent. strength)	20 ,,
Weak methanol	7 ,,
Ratio of reflux	2·6 to 1
Consumption per gallon of methanol made—	
Steam (at 25 lbs. pressure)	30 lbs.
Cooling water	40 galls.
Time of working	5 hours

Recovered Carbon Disulphide.

The crude carbon disulphide obtained from the neutralizing operation is a black evil-smelling liquid, consisting principally of carbon disulphide (about 85 per cent.) and dissolved free sulphur, and having a specific gravity of 1·30. On washing with dilute caustic soda solution, the colour becomes brown, and the odour less objectionable, the loss in washing being about 5 per cent. Carbon disulphide recoverable is 50 per cent. to 60 per cent. of the amount removed from the benzole.

Washing with caustic soda and strong sulphuric acid, followed by careful fractionating, will yield rectified carbon disulphide of fair quality. So far this has only been done on a laboratory scale, the quantity produced being too small to justify putting in plant. Meantime the crude material is accumulating slowly, and is stored in drums after being made alkaline by addition of a little caustic soda.

Suggestions for dealing with this by-product are:—

(1) Disposal in crude form after washing to makers of carbon disulphide.

(2) In the event of extension of the process, working up the crude in remunerative quantities at central refineries.

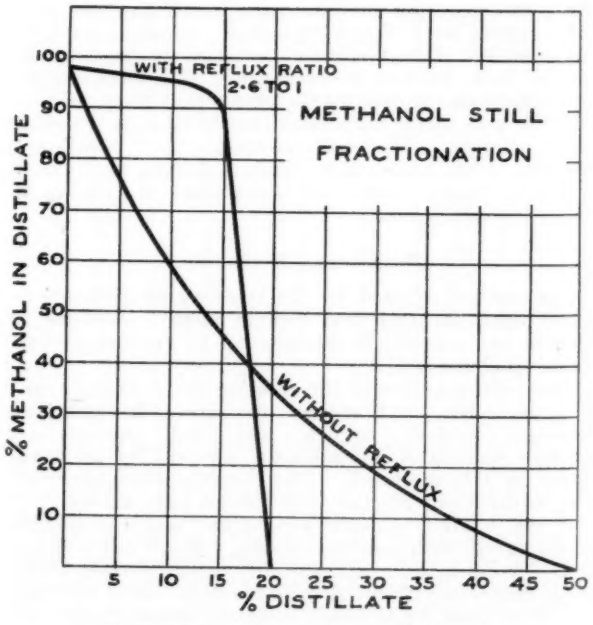

FIGURE 3.—*Fractionation of Methanol.*

Capacity of the Plant.

The plant and the method of working have been described in some detail with the object of affording information which may be of use in determining the plant

required for removal of any specific quantity of carbon disulphide.

At present working about 12 hours per week, the plant is dealing with the residues obtained from treatment of 7,500 gallons of benzole weekly, the sulphur as carbon disulphide being reduced from ·35 per cent. to ·10 per cent. This reduction corresponds to the removal of about 200 lbs. of carbon disulphide per week. Obviously much larger quantities can be dealt with, but it is probable that if considerable quantity of sulphur is to be removed, a larger plant with reduced labour cost will be more economical.

As now worked, the process is to some extent a spare-time job for the attendant, and little extra labour is required. It is estimated that a plant, of the capacity described and built of new material, can be erected at a cost of about £300.

Excise and Other Regulations.

Methanol of " blending " quality (about 99 per cent. methyl alcohol) may be purchased without restriction.

Before any recovery of methanol by distillation may be attempted, permission must be obtained from the local Excise Authority. No fee for this is charged, but it may be necessary to submit a drawing of the still with particulars of the purpose for which it is required. The Certificate of Registration for the manufacture of benzole under the Alkali, &c., Works Regulation Act, 1906, must be extended to cover the manufacture of carbon disulphide; no additional fee is charged.

Cost of the Process.

Particulars of the cost of removal of sulphur from benzole by the methanol-soda process can only be tentative until longer experience of working has been gained.

Much depends upon the percentage of methanol which can be recovered. Careful estimations of individual batches have shown that at least 90 per cent. recovery has been obtained. It is not yet known whether this can be maintained over a period or improved upon, but at least 85 per cent. can be recovered with certainty.

The cost per unit of sulphur removed is lower when the initial content of carbon disulphide in the benzole is high, the reaction proceeding more efficiently under these circumstances. Assuming a recovery of 85 per cent. of methanol, the cost of removing carbon disulphide from benzole (in pence per gallon of benzole) may be stated as follows:—

—	Sulphur Reduced from 1·0 Per Cent. to 0·1 Per Cent.	Sulphur Reduced from 0·35 Per Cent. to 0·1 Per Cent.
1	2	3
Chemicals, steam, and labour . .	0·32	0·11
Interest and depreciation of plant—£300 at 15 per cent., 300,000 galls per annum	0·04	0·04
Total	0·36	0·15
Cost per gallon, per 0·1 per cent. sulphur removed	0·04	0·06

If by careful working a recovery of 90 per cent. of methanol can be maintained these figures will be reduced to ·032 and ·053 respectively. These costs, which are based upon actual results, are given with some reserve. Nothing is yet known regarding possible corrosion troubles, though these are not expected. On the other hand, further study of this new process may lead to improvements which may reduce the cost. It will be seen from the above figures that the cost of removal of sulphur from benzoles of low sulphur content may be reduced by applying the methanol treatment to forerunnings instead of to the whole of the benzole. Against this saving, however, must be placed the cost and inconvenience of the separation of forerunnings. Both methods have been tried, and, under the circumstances, treatment of the whole of the benzole is considered to be more suitable.

The methanol soda process, interesting as it is in the chemistry involved, is not a pleasant process to work. During and after neutralization, very disagreeable odours are evolved. Nuisance from this source may be reduced by working up the residues immediately and by careful attention to joints on the plant. The possibility of increased risk of fire has had consideration. Methanol itself is probably no more dangerous than benzole. A mixture of 40 per cent. methanol in water has a flash point of 85° F. (Abel); the residues therefore are not highly inflammable. The recovered carbon disulphide is of course a potential danger. In the process as worked, no distillation of carbon disulphide is carried out; the crude is produced under a cold aqueous layer and is drawn off through a pipe which extends to some distance from the plant. The risk is therefore reduced to a minimum.

Benevolent Fund of the Institution of Gas Engineers.

Report of the Committee of Management of The Benevolent Fund of The Institution of Gas Engineers for the Year 1933-34 and the Accounts for the Year 1933.

The Committee of Management of The Benevolent Fund of The Institution of Gas Engineers has pleasure in submitting to the Subscribers and Donors its Report for the Year 1933-34, together with the audited Accounts for the Year ended 31st December, 1933, and a List of Subscriptions and Donations to the Fund in 1933.

The number of cases assisted by the Fund in 1933 was twenty and the amount expended was £755 as compared with £755 10s. spent in relieving twenty-one cases in 1932. The expenses of the Fund have been confined, as is customary, to the necessary outlay for printing, stationery, and postage.

Contributions received in 1933 totalled £659 6s. (being £550 16s. in Subscriptions and £108 10s. in Donations), as compared with a total of £821 18s. 6d. in 1932 and £782 12s. 2d. in 1931. The reduced income of £162 12s. 6d. from Contributions is almost wholly due to decreased revenue from Donations, the receipts from Subscriptions having been maintained.

The number of Contributors to the Fund in 1933 was 867, as compared with 873 in 1932 and 821 in 1931. The membership of the Institution on 31st December, 1933, was 1,494. It is regretted that a much larger proportion of the members of the Institution do not contribute to the Fund.

The Committee of Management expresses its gratitude to all Contributors to the Fund and is very appreciative of the continued assistance received from the District Associations affiliated to the Institution. It is hoped that Members who have not in the past subscribed to the Fund will become contributors, in order that adequate assistance may be afforded to deserving applicants.

At the forthcoming General Meeting, Mr. R. H. Ruthven (Ramsgate) and Mr. W. B. McLusky (Halifax) retire from the Committee, when they will have completed three years' continuous service. As their successors, the Committee have nominated for election by the Contributors, Mr. S. E. Halliwell (Bristol) and Mr. D. M. Henshaw (Huddersfield).

Correlation of Costs and Gas Charges with Particular Reference to Working Results at Macclesfield

By H. CURTIS, M.Inst.Gas E.,

Engineer and Manager, Macclesfield Corporation Gas Department.

Prior to 1923 the system of charging for gas in Macclesfield was a flat rate with slight reductions in price for power purposes, the rate being equal to 11½d. per therm.

As a preliminary attempt to give some advantage to the more remunerative consumers and as a means of encouragement to small consumers to increase their consumption, a new scale of charges was introduced in 1923. The details of the scale are given in Table I. The scheme was a form of block system with reductions in steps, commencing at 40 therms per quarter. Two further reductions were made at 100 and 250 therms per quarter respectively, after which the rate became a flat one at 9d. per therm.

TABLE I.—*Scale of Charges for Consumption of Gas Through Ordinary Meters (Other than Power)*—1923-24

Where the quarterly consumption is—	
(1) Less than 40 therms	10½d. per therm
(2) 40 therms and less than 100 therms	10d. ,,
(3) 100 therms and less than 250 therms	9½d. ,,
(4) 250 therms and over	9d. ,,

This system, together with its subsequent developments, is very clearly shewn by the several graphs of Figure 1. Four reductions in the price were made in the years 1924, 1925, 1926, and 1927. It will be noted that the larger consumers receive a greater percentage reduction than smaller consumers, although a reduction by the same amount per therm was made in each case. It will be noted further, and this is an important point, that the first reduction of ½d. per therm was made after the comparatively small consumption of 40 therms per quarter. It was held that, if such a system as this was to be effective in encouraging the use of gas, a reduction must be given at as early a stage as possible. It should be pointed out, too, that not only is a reduction given as the consumption increases, but that, where consumers own apparatus similar to that provided free by the department, viz., cookers and fires, a further reduction of ½d. per therm is made on the whole consumption when this exceeds 40 therms per quarter.

The Power Scale.

In the scale of charges for power purposes (see Table II.) certain conditions are imposed, the main one of which is that in the case of gas engines the brake horsepower of the engine for charging purposes is not the rated capacity of the engine, but the power as ascertained by running the engine on the full load available. For example, if a 20-H.P. engine is installed, but the power actually developed on full load is only 15 H.P., the assessment on the scale is fixed at the lower figure. Further, in order to qualify for inclusion on the power scale the quarterly consumption must not be less than 60 per cent. of the assessment. This further qualification constitutes, to some extent, a demand charge. It is possible, for instance, for a consumer who has installed a 20-H.P. engine, and who uses it regularly, to pay a less average price per therm on a smaller consumption than a consumer who has installed a 75-H.P. engine, but who does not use it sufficiently to consume 60 per cent. of the quantity of gas upon which the assessment is based.

TABLE II.—*Scale of Charges for Quarterly Consumptions of Gas by Meter for Power Purposes Only—June*, 1927.

(*a*) Where the consumption of gas per quarter does not reach 60 per cent. of the assessment of the brake horsepower of maximum demand of the engine, a flat rate of 6½d. per therm.

(*b*) Where the consumption of gas per quarter is above 60 per cent. of the assessment of the brake horsepower of maximum demand of the engine, the charge for gas consumed to be as follows:

	CHARGE PER QUARTER.
For the first 125 therms	6·00d. per therm
,, next 125 ,,	5·75d. ,,
,, ,, 125 ,,	5·50d. ,,
,, ,, 125 ,,	5·25d. ,,
,, ,, 250 ,,	5·00d. ,,
,, ,, 250 ,,	4·75d. ,,
,, ,, 800 ,,	4·50d. ,,
,, ,, 800 ,,	4·40d. ,,
,, ,, 800 ,,	4·30d. ,,
,, ,, 800 ,,	4·20d. ,,
,, ,, 800 ,,	4·10d. ,,
For any number over 5,000 ,,	4·00d. ,,

All power consumers must enter into an agreement to be prepared by the Town Clerk.

Free Appliances.

In 1923 a substantial profit had been made, and the Committee decided to abolish cooker and gas-fire rents. In 1926, however, the Author was able to shew that the increased consumption obtained from these appliances was not such as to warrant the continuance of free hire, and, in spite of the difficulties and possible troubles which it was feared would accompany a reversal of this policy, it was decided gradually to bring free hire to an end. It was arranged that all free appliances already issued should be allowed to remain, but that any further issues of cookers and fires should be charged with 10s. towards the cost of fixing the apparatus. Consumers who really wanted a cooker or a fire willingly paid this charge. This arrangement is still in force, but since its inception not a single cooker so far has been bought by the department for "free hire." The incidental saving in expenditure on this account is shewn in Table IV.

Sale of Appliances.

On the other hand, we have developed the sale and hire-purchase of apparatus of a much higher quality than that formerly issued on "free hire," with the result that the consumer, feeling that it is his property, takes much greater care of it, with a corresponding saving in maintenance charges to the undertaking.

It was not until 1929 that a complete census of apparatus on the district was taken, and I am, therefore, not in a position to state exactly the total number of cookers and fires owned by consumers prior to that year. It is obvious, however, from the figures available that the free issue of appliances is a very questionable policy.

The General Strike.

In 1926, the year of the general strike, we were faced with a repetition of conditions similar to those of the 1921 coal stoppage, when the balance-sheets shewed losses due to the high prices which had to be paid for coal. With this experience in our minds we prevailed on the Council to accept our recommendation of an immediate increase of 25 per cent. in the prices of gas. The result of this prompt action was that the department showed such a balance for the year ending March, 1927, that, whereas quite a number of undertakings were increasing their prices at that date to make good their

losses, we were in the happy position of being able to make a substantial reduction.

TABLE III.—*Scale of Charges for Consumption of Gas Through Ordinary Meters (Other than Power)—June, 1927.*

Where the quarterly consumption is—

(1) Less than 40 therms	7½d. per therm
(2) 40 and less than 100 therms	7d. ,,
(3) 100 and less than 250 therms	6½d. ,,
(4) 250 therms and over	6d. ,,

In cases of Nos. 2, 3, and 4 a reduction of ½d. per therm is allowed when consumer owns gas appliances approved by the Gas Engineer and of the type which are supplied free by the Corporation.

MARGINAL RELIEF.

If the consumption of gas is near the figure where there is a reduction in price per therm (*e.g.*, 40, 100, and 250 therms), consumers will not be charged more for a less quantity of gas consumed than if they had consumed the quantity necessary to qualify for the next reduction in the Scale of Charges. A minimum sum of 3s. per quarter will be charged where a meter is used as a standby.

The scale of charges issued in June, 1927, is given in Table III. The maximum price was 7½d. per therm, with reductions at the same points as in the previous scale, reaching a flat rate of 6d. per therm with a quarterly consumption of 250 therms.

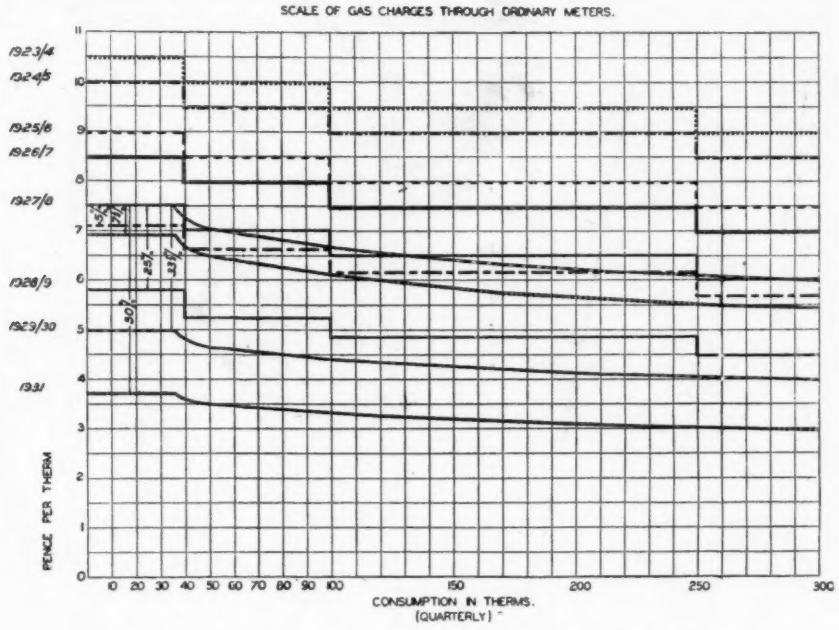

FIGURE 1.—*Scale of Gas Charges through Ordinary Meters.*

The Seasonal Charge.

In May, 1928, we had arrived at a position where we could again consider a reduction in the price of gas, and in collaboration with the Chairman of the Gas Committee, himself an electrical engineer, the scheme of Seasonal Rebates was put forward and accepted by the Council.

The theory of the scheme was to increase the load factor by stimulating demand in the light season, as is illustrated by the following extracts from the Chairman's speech in which he presented the proposal to the Gas Committee and the Council.

> "Satisfactory as the trading results of this department have been during recent years, I consider that the figures now presented compare more than favourably with any previous results.
>
> It has to be remembered that during the last year we not only removed the advance of 25 per cent. put on due to the coal stoppage, but, in addition, we reduced the prices charged for gas by 1½d. per therm.
>
> . . . I am, therefore, in the very fortunate position of being able to suggest to you a still further reduction in the price of gas. I have given the amount and the form that this reduction shall take, very careful consideration, and I am now going to suggest to you an entirely novel proposition.
>
> The point is, what can be done to increase the consumption in the lightest quarters?
>
> It is certainly our experience and, I believe, a universal one, that, when the price of gas goes down the consumption at once increases, and, conversely, when the price goes up, the consumption falls off. This may be due to the fact that consumers are not quite so economical when the price goes down, and possibly gas is put to more use when it is cheap. . . .
>
> I have discussed the proposal I am about to make with the Borough Accountant and the Gas Engineer, and we are all in agreement upon it.
>
> What I, therefore, propose is, that a very large rebate shall be offered for the summer quarters, and a smaller rebate for the winter quarters, so that the consumption shall be more stimulated when we most desire it.
>
> The rebates I suggest are, for the summer quarters 25 per cent. and for the winter quarters 5 per cent.
>
> I venture to think that, if we adopt this proposal of a special rebate for the summer quarters, it will not be long before this method is followed by many other concerns in the gas world, and possibly also in the electrical world."

The scheme was, thus, what may be termed a Seasonal Differential Charging Scheme, and its object was to increase the demand in the summer, when we could very easily meet it, and if possible to equalize the load curve to some extent while increasing the total annual consumption so that the overhead charges per therm would be automatically reduced.

It will be seen (Table IV.) that we were in the fortunate position of having a surplus on the previous year's working so that we could, in accordance with our Statutory Powers, make a reduction in the price charged for gas.

RESULTS.

SUMMARY OF RESULTS.

The Seasonal Differential Charging Scheme was accepted and put into operation. Advantage was taken

TABLE IV.—*Summary of Financial Statements, 1923-33, Macclesfield Corporation Gas Department.*

Line No.	—	1923.		1924.		1925		1926.		1927.		1928.		1929.		1930.		1931.		1932.		1933.	
		Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.	Total for Year.	Per Therm in Pence.
1	2	3	4	5	6.	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Manufacture—	£		£		£		£		£		£		£		£		£		£		£	
1	Coal and oil	18,813	4·365	18,923	4·113	21,343	4·363	20,304	3·817	27,235	4·7518	17,018	2·9445	15,939	2·6300	17,563	2·7703	17,219	2·6186	17,877	2·5819	18,183	2·6410
2	Salaries	1,296	0·294	1,276	0·277	1,135	0·233	1,102	0·207	1,093	0·1907	1,223	0·2091	1,229	0·2028	1,243	0·1961	1,234	0·1888	1,043	0·1559	1,032	0·1503
3	Wages (carbonizing and purifying)	3,768	0·856	3,481	0·757	3,575	0·739	3,210	0·603	3,264	0·5694	3,087	0·5280	3,083	0·5087	3,211	0·5066	3,158	0·4831	3,136	0·4686	3,075	0·4432
4	Repairs and maintenance	4,767	1·083	8,026	1·745	4,994	0·958	6,594	1·239	4,172	0·7279	4,079	0·6976	4,961	0·8185	4,529	0·7144	2,776	0·4246	2,734	0·4086	3,700	0·5093
5	National insurance	227	0·056	250	0·056	243	0·050	221	0·042	250	0·0436	261	0·0446	244	0·0402	248	0·0391	239	0·0365	250	0·0374	285	0·0392
6	Workmen's holiday pay	819	0·049	814	0·047	848	0·051	845	0·046	821	0·0385	830	0·0393	866	0·0438	862	0·0412	857	0·0393	880	0·0418	853	0·0348
7	Ammonia	..	..	..	..	..	..	..	..	491	0·0856	870	0·1488	763	0·1259	648	0·1022	418	0·0639	268	0·0391	20	0·0028
8	Repairs and renewals of retorts	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1,450	0·2287	1,874	0·2876	1,920	0·2869	1,493	0·1939
9	Purifying materials	7	0·002	3	0·001	46	0·009	43	0·008	5	0·0008	..	..	..	..	..	..	..	..	..	..	..	..
			6·705		6·996		6·409		5·962		6·4083		4·6119		4·3699		4·5986		4·1424		4·0202		3·9965
	Less Residuals—																						
10	Coke	4,217	0·958	4,985	1·084	4,979	1·016	4,648	0·873	5,597	0·9785	3,486	0·5961	4,431	0·7311	3,725	0·5876	3,882	0·5938	3,790	0·5664	4,101	0·5644
11	Tar	2,618	0·595	3,345	1·158	2,900	0·592	2,859	0·537	3,497	0·6101	4,614	0·7891	2,905	0·4793	2,289	0·3610	2,960	0·3457	1,953	0·2918	2,598	0·3508
12	Ammonia	408	0·093	1,197	0·260	775	0·158	603	0·130	..	..	..	..	..	..	..	..	..	..	..	..	..	..
13	Spent oxide	34	0·007	6	0·001	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
			1·653		2·503		1·766		1·540		1·5886		1·3852		1·8104		0·9486		0·9395		0·8582		0·9819
14	Net cost into holders		5·052		4·493		1·636		4·422		4·8197		3·2267		3·1595		3·6500		3·8029		3·1630		3·0753
	Distribution—																						
15	Inspectors' wages and uniforms	1,234	0·280	1,442	0·313	1,348	0·296	1,417	0·266	1,488	0·2596	1,587	0·2611	1,506	0·2484	1,566	0·2470	1,655	0·2532	1,720	0·2570	1,747	0·2405
16	Mains and services	1,507	0·342	4,563	0·992	3,230	0·659	2,791	0·525	1,302	0·2271	2,003	0·4451	2,369	0·3908	1,711	0·2698	1,704	0·2607	1,929	0·1941	2,032	0·2797
17	Prepayment meters	2,012	0·457	1,932	0·484	1,857	0·379	2,299	0·419	2,289	0·4168	2,585	0·4421	2,711	0·4473	3,079	0·4857	2,907	0·4447	2,847	0·4355	2,439	0·3357
18	Cookers and gas fires	2,429	0·552	1,702	0·369	1,218	0·248	784	0·147	1,453	0·2535	1,187	0·2030	897	0·1480	549	0·0866	205	0·0313	..	..	..	..
19	Ordinary meters	1,669	0·365	1,549	0·337	2,158	0·439	903	0·170	991	0·1729	615	0·1052	548	0·0911	607	0·0957	671	0·1026	686	0·1025	920	0·1266
20	Showroom	399	0·091	318	0·068	490	0·100	285	0·053	339	0·0591	338	0·0578	355	0·0586	356	0·0562	388	0·0593	325	0·0486	297	0·0409
			2·087		2·503		2·101		1·580		1·3890		1·3143		1·3826		1·2410		1·1518		1·0277		1·0234
21	Rent, rates and taxes	3,520	0·800	6,310	1·378	4,765	0·937	5,402	1·015	4,968	0·8668	3,933	1·1046	4,704	0·7762	5,302	0·5326	4,932	0·7544	4,842	0·7236	4,722	0·6489
	Management—																						
22	Salaries, &c.	855	0·194	846	0·180	830	0·170	900	0·169	827	0·1442	800	0·1368	773	0·1275	680	0·1072	745	0·1140	771	0·1152	751	0·1034
23	Stationery and printing	327	0·043	394	0·086	252	0·051	237	0·046	114	0·0198	181	0·0310	212	0·0350	207	0·0327	208	0·0318	133	0·0198	153	0·0210
24	Bad debts	185	0·028	140	0·030	82	0·017	153	0·021	70	0·0122	109	0·0186	83	0·0104	94	0·0148	85	0·0130	178	0·0257	61	0·0084
25	Interest on deposits	16	0·004	16	0·003	16	0·003	18	0·003	..	..	16	0·0031	17	0·0028	16	0·0025	15	0·0023	13	0·0019	12	0·0016
26	Bank interest	1,406	0·337	805	0·045	867	0·054	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
27	Property rents	..	..	..	..	..	..	21	0·003	..	..	..	..	..	..	..	..	..	..	..	..	..	..
28	Contribution to chief officials' salaries	..	..	..	..	..	..	..	..	..	..	430	0·0735	430	0·0709	430	0·0678	430	0·0657	430	0·0643	430	0·0592
29	Superannuation	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	273	0·0265	395	0·0590	408	0·0575
			0·506		0·344		0·895		0·248		0·1762		0·2630		0·2466		0·2250		0·2533		0·2859		0·2511
			8·445		8·719		7·969		7·259		7·2517		6·1086		5·3665		5·6686		5·3624		5·1992		4·9997
	Less—																						
30	Bank interest	..	..	..	..	..	..	73	0·013	302	0·0536	585	0·0898	603	0·1009	694	0·1094	542	0·0829	586	0·0876	456	0·0588
31	Cooker rents	956	0·217	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
32	Gas fire rents	700	0·159	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
33	Meter rents	861	0·195	829	0·180	852	0·175	880	0·166	895	0·1561	898	0·1536	915	0·1441	919	0·1450	933	0·1427	938	0·1403	952	0·1310
34	Property rents	280	0·064	319	0·069	248	0·051	..	..	241	0·0420	243	0·0415	304	0·0501	297	0·0468	157	0·0240	152	0·0222	195	0·0268
35	Profit on sales of apparatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	223	0·0352	502	0·0768	669	0·1002	472	0·0650
			0·635		0·249		0·226		0·179		0·2307		0·2849		0·2942		0·3364		0·3864		0·3503		0·2856
			7·810		8·463		7·743		7·080		7·0010		5·8237		5·2723		5·3382		5·0360		4·8489		4·7141
	Add—																						
36	Interest on stock	3,003	0·682	3,055	0·664	4,084	0·833	4,031	0·737	2,370	0·4135	2,432	0·4159	3,158	0·5211	3,499	..	3,416	..	3,639	..	3,548	..
37	Sinking fund	632	0·144	632	0·137	616	0·126	1,781	0·334	1,488	0·2596	1,488	0·2545	1,911	0·3153	..	..	..	..	..	..	..	..
			0·826		0·801		0·959		1·071		0·6731		0·6704		0·8364		0·5519		0·5235		0·5437		0·4883
38	Gross cost per therm		8·636		9·264		8·702		8·151		7·6741		6·4941		6·1087		5·8821		5·5585		5·3926		5·2034
39	Average price realised		11·826		10·21		9·02		8·7		9·55		5·121		6·69		6·036		6·021		5·582		5·356
40	Net profit for year	£15,941		£1,928		£80		£9,418		£1,014		£6,304		£1,085		£318		£2,197		£987		£678	

of its introduction to issue a price list in which the anomalies due to the marginal cases, inevitable in stepped scales of charges, were removed.

With the introduction of the new system the stepped scale was smoothed out into a continuous curve, and a price list was issued. Every consumer was thus in possession of the basis of the charges made without the necessity of calculation. It was, in fact, a ready reckoner in which he could read directly the amount of the bill to be rendered to him. All further adjustments were made in the form of discounts for cash, based upon this price list.

The seasonal rebates (5 per cent. in the winter and 25 per cent. in the summer) of the first year, 1928/9, of the new system were calculated to give back to the consumers the profit which had been realized in the previous year, and which amounted, roughly, to 10 per cent.

It was, of course, with the keenest interest that we watched the effect on the consumption month by month, and we were greatly surprised to find that, though there was a gratifying increase in the summer demand, this increase persisted during the winter, and that the levelling up of the load factor was not realized to any great extent.

The reason is really not far to seek. During the summer months, when gas is cheap, the consumer is educated up to a higher standard of comfort, which he is by no means inclined to forego during the winter. Gas fires and water heaters, particularly, are installed in the summer and they are retained in the winter to a very large extent. A constant supply of hot water in the kitchen and bathroom, the convenience and cleanliness of gas fires in rooms occasionally used, are seen to be advantages which are worth having even at the higher winter prices.

The result of the first year's working was such that, not only had output been increased, but a sufficient profit had been made to warrant an increase in the discounts. Accordingly in 1929 discounts were increased to 33⅓ per cent. in the summer and 7½ per cent. in the winter, see Figure 1.

At the end of the financial year, March, 1930, we found we had a credit balance in spite of having distributed rebates to the extent of £8,083, as against £3,596 in the previous year, so that though we did not get the

TABLE V.—*Summary of Technical Results*, 1923-33. *Macclesfield Corporation Gas Department.*

Year.	Total Number of Therms.		Gas Sold.				Gas Used on Works, &c.	Unaccounted-for Gas.		Average Consumption per Prepayment Meter. Therms.	Average Cash Received per Prepayment Meter.
	Made.	Sold or Used.	Ordinary Meters.	Power, Included in Ordinary.	Prepayment Meters.	Public Lamps.		Therms	Per Cent.		
1	2	3	4	5	6	7	8	9	10	11	12
											£ s. d.
1923	1,181,611	1,069,426	606,696		424,325	25,279	13,126	112,185	9·5	70·88	3 15 9
1924	1,264,343	1,118,881	626,552		448,721	28,812	14,796	145,462	11·6	73·43	3 10 2
1925	1,289,567	1,191,404	650,021		494,103	32,141	15,139	98,163	7·6	78·20	3 5 8
1926	1,372,874	1,290,777	673,433	110,760	566,381	36,966	13,997	82,097	5·98	88·67	3 12 7
1927	1,449,130	1,387,568	700,545	108,814	640,434	34,556	12,433	61,162	4·22	99·15	4 6 11
1928	1,493,814	1,417,578	714,451	118,800	650,043	38,876	14,208	76,236	5·1	96·79	3 15 7
Increase 1923-28, per cent.		32·55	17·76		53·19					36·5	
1929	1,580,057	1,468,291	740,951	123,780	672,702	40,847	13,791	111,766	7·07	98·16	3 1 9
1930	1,624,589	1,535,602	712,768	120,327	755,048	53,689	14,097	88,987	5·48	108·48	3 0 8
1931	1,663,158	1,582,784	725,362	112,754	773,180	70,452	13,790	80,374	4·83	108·99	3 1 9
1932	1,671,650	1,633,139	736,707	109,150	808,287	74,579	13,566	38,511	2·30	112·54	2 18 6
1933	1,822,136	1,771,631	826,758	126,504	850,864	80,042	13,967	50,505	2·77	117·66	3 0 0
Increase 1928-33, per cent.		24·98	15·71		30·89					21·6	
Increase 1923-33, per cent.		65·67	36·27		100·52	216				66	20·6 reduction

Year.	Therms Made (Coal Gas) per Ton.	Capital Employed.	Capital Employed per Therm Sold and Used.	Rent, Rates, and Taxes.	Total Gas Revenue.		Rebate for Year.		Scales and Discounts Operative.		Average Price Received (Net) per Therm Sold.
					Gross.	Net.	Total.	Percentage of Gross Gas Revenue.	Summer.	Winter.	
1	13	14	15	16	17	18	19	20	21	22	23
		£	Pence.	£	£	£	£		Per Cent.	Per Cent.	Pence.
1923	80·23	94,000	21·09	3,520		52,050					11·826
1924	80·92	96,175	20·64	6,310		46,972					10·210
1925	80·97	120,331	24·24	4,765		44,239					9·020
1926	81·34	121,200	24·04	5,402		46,296					8·700
1927	88·05	121,500	21·00	4,968		54,770					9·550
1928	95·81	121,500	20·57	5 933		47,470					8·121
Increase 1923-28, per cent.											
1929	95·53	121,500	19·86	4,704	44,146	40,550	3,596	8·14	25	5	6·690
1930	99·31	121,500	18·99	3,502	46,323	38,240	8,083	17·45	25 & 33⅓	7½	6·036
1931	99·43	121,500	18·42	4,932	47,632	39,237	8,395	17·62	33⅓	7½	6·002
1932	101·93	121,500	18·00	4,842	48,856	37,682	11,174	22·87	33⅓ & 50	7½	5·582
1933	101·97	121,500	16·59	4,722	52,362	39,231	13,131	25·08	50	7½	5·356
Increase 1928-33, per cent.											
Increase 1923-33, per cent.											

equalization of summer and winter loads to the extent which we had expected, we were able to increase the discounts to 50 per cent. in the summer, while leaving the 7½ per cent. in the winter. And these discounts have remained in force ever since.

The effect of the scheme on the annual results is shewn in Table V., which exhibits the increase of 24·98 per cent. in the total quantity of gas sold as between 1928 and 1933.

It will be asked, how is this increased consumption accounted for? I have already referred to the effect of the seasonal discount scheme on the domestic consumer, but there have been notable increases in the industrial sphere as well. The low price of gas has enabled us to enter the field of steam raising in factories, particularly where there is not a large amount of steam used other than for heating. In these cases gas-fired boilers have been installed for use during the period of the larger discount. It may be argued that a load like this is unprofitable, but it does help to reduce the overhead charges when these are spread over the minimum demand. It is conceivable, however, that cases of this kind, in spite of the experience above referred to, might increase the summer demand to such an extent as to cause inconvenience in carrying out repairs to manufacturing plant. In that case the charges to seasonal consumers of the industrial type would have to be revised.

Table IV. is a complete collection of the financial summaries for the years 1923-1933 inclusive. The number of gas cookers and gas fires in use has already been referred to. Table IV. also shews the rapid falling off in the expenditure upon cookers and gas fires supplied for free hirage, line 18, which disappears entirely after 1931; cooker and gas fire rents, lines 31 and 32, do not appear after 1923, while profit on sales of appliances, line 35, appears in 1930.

Table V. gives the technical results. The increase in the annual consumption over the whole period, 1923-33, was 65·67 per cent. That the reduction in price and the increases in rebates have proved popular with the smallest consumers is shewn by the increases in the number of prepayment meters and the consumption through each, accompanied by a reduction in the quantity of cash received per meter, columns 11 and 12.

The rapid increase in the make per ton from the year 1928 is due to the introduction of the new model vertical retort, in which the efficiency of the steaming process is greatly increased. The carbonizing plant consists of 32 continuous vertical retorts, which were installed in 1913. The steaming process was introduced in these retorts by Mr. Blundell in 1917, but it was not until 1925 that the first section of 16 retorts were rebuilt on the new model specially designed for the process. These were followed by 8 further retorts in 1926 and the last 8 retorts in 1929. The effect on the make per ton is clearly shewn in Table V.

EXAMPLES OF RESULTS.

Table VI. is constructed of details of five examples of the application of the scheme to domestic consumers. Houses A and B are instances in which the consumer was induced to change over from mixed gas and coal to all gas. Consumer A did not, in the first place, own any of the appliances, and, therefore, did not qualify for the ½d. per therm rebate, but when he turned over to all-gas he bought the appliances and obtained the

TABLE VI.—*Examples Showing Application of Seasonal Differential Charging System.*

CONSUMER "A1."—USING GAS AND COAL.

Quarter.	Consumption. Cu.Ft.	Consumption. Therms.	List Price Charged.	Meter Rent.	Rebate.	Net Amount Charged.	Net Cost per Therm.
1	2	3	4	5	6	7	8
			£ s. d.	s. d.	£ s. d.	£ s. d.	Pence.
September, 1931	9,200	38·64	1 3 8	1 9	0 11 10	0 13 7	
December, 1931	11,800	49·56	1 9 6	1 9	0 2 3	1 9 0	
March, 1932	9,500	39·90	1 4 2	1 9	0 1 10	1 4 1	
June, 1932	5,600	23·52	0 14 8	1 9	0 7 4	0 9 1	
Totals	36,100	151·62	£4 12 0	7 0	£1 3 3	£3 15 9	6·0
					Annual coal cost	£6 10 0	
					Total cost for gas and coal	£10 5 9	

In the above case the consumer did not own any of the appliances, and, therefore, did not qualify for the ½d. per therm rebate.

CONSUMER "A2."—USING GAS ONLY.

September, 1932	26,000	109·20	3 0 3	1 9	1 10 1	1 11 11	
December, 1932	52,600	220·92	5 4 11	1 9	0 7 11	4 18 9	
March, 1933	47,000	197·40	4 14 10	1 9	0 7 2	4 9 5	
June, 1933	32,800	137·76	3 8 6	1 9	1 14 3	1 16 0	
Totals	158,400	665·28	£16 8 6	7 0	£3 19 5	£12 6 1	4·62

In the same house using gas only the consumer had now bought the appliances and qualified for the ½d. per therm rebate.

CONSUMER "B1."—USING GAS AND COAL.

Quarter.	Consumption. Cu.Ft.	Consumption. Therms.	List Price Charged.	Meter Rent.	Rebate.	Net Amount Charged.	Net Cost per Therm.
1	2	3	4	5	6	7	8
			£ s. d.		£ s. d.	£ s. d.	Pence.
September, 1931	14,900	62·58	1 13 9	..	0 16 11	0 16 10	
December, 1931	17,900	75·18	1 19 10	..	0 3 0	1 16 10	
March, 1932	18,100	76·02	2 0 4	..	0 3 0	1 17 4	
June, 1932	15,900	66·78	1 15 8	..	0 17 10	0 17 10	
Totals	66,800	280·56	£7 9 7	..	£2 0 9	£5 8 10	4·65
					Annual coal cost	£5 10 0	
					Total cost for gas and coal	£10 18 10	

CONSUMER "B2."—USING GAS ONLY.

December, 1932	45,600	191·52	4 12 2	..	0 6 11	4 5 3	
March, 1933	43,700	183·54	4 8 8	..	0 6 8	4 2 0	
June, 1933	19,400	81·48	2 2 11	..	1 1 5	1 1 6	
September, 1933	12,000	50·40	1 7 11	..	1 4 0	1 3 11	
Totals	120,700	506·94	£12 11 8	..	£2 19 0	£10 12 8	4·7

In both cases of House "B" the consumer owned both meter and appliances, and, therefore, qualified for the ½d. per therm rebate.

CONSUMER "C."—Has Own Apparatus.

Quarter.	Consumption. Cu.Ft.	Consumption. Therms.	Amount as per List.	Rebate.	Net Amount Charged.	Average Price per Therm.
1	2	3	4	5	6	7
			£ s. d.	£ s. d.	£ s. d.	Pence.
March, 1933	60,900	255·68	5 19 9	0 9 0	5 10 9	
June, ,,	43,600	183·12	4 8 5	2 4 2	2 4 3	
Sept., ,,	33,000	138·60	3 8 11	1 14 6	1 14 5	
Dec., ,,	67,800	284·76	6 12 4	0 9 11	6 2 5	
Totals	205,300	862·26	£20 9 5	£4 17 7	£15 11 10	4·34

CONSUMER "D."

March, 1933	47,700	200·34	5 4 4	0 7 10	4 16 6	
June, ,,	24,800	104·16	2 17 9	1 8 11	1 8 10	
Sept., ,,	4,000	16·80	0 10 6	0 5 3	0 5 3	
Dec., ,,	21,600	90·72	2 10 11	0 3 10	2 7 1	
Totals	98,100	412·02	£11 3 6	£2 5 10	£8 17 8	5·17

CONSUMER "E."

March, 1933	87,700	368·34	9 4 3	0 13 10	8 10 5	
June, ,,	38,000	159·60	4 4 10	2 2 5	2 2 5	
Sept., ,,	2,200	9·24	0 5 9	0 2 10	0 2 11	
Dec., ,,	71,900	301·98	7 12 2	0 11 8	7 0 6	
Totals	199,800	839·16	£21 7 0	£3 10 9	£17 16 3	5·09

rebate. Consumer B owned the appliances both before and after the change, and obtained the rebate.

The examples C, D, and E illustrate how the present differential charges operate. Consumer C is an instance of a fairly regular seasonal demand, and consumers D and E are instances of irregular seasonal demand.

It is suggested that the examples illustrated in Table VI. will repay study. In the case A1 we have a moderately good domestic consumer using Corporation appliances. In case A2 the same consumer has developed into a very good consumer. His consumption has increased four-fold, and his demand is as nearly regular, seasonally, as one could expect. His average price has fallen from 6·0d. to 4·62d. per therm, allowance being made in the latter figure for the rebate of ½d. per therm for the use of the consumer's own appliances.

Consumer B presents a very different picture. Case B1 is that of a good consumer. His seasonal demand is exceptionally regular and his average price, at the prices then ruling, was 4·65d. per therm for the year's consumption of 280 therms. This price should be compared with the case A2, who paid 4·62d. per therm for the year's consumption of 665 therms.

When, however, consumer B goes on to " all-gas," case B2, his winter consumption has increased without a corresponding advance in his summer consumption, which had, no doubt, already reached saturation point. His demand is not nearly so good from the point of view of regularity as it was before he changed over, and his average price shows a very slight increase. In fact, this is an instance of a disguised " demand charge." For the consumers A and B we have also the very interesting comparison of the combined cost of the gas and coal with " all-gas."

Consideration of Results.

No doubt the favourable response to the scheme by the Committee and the Council was due to the very able manner in which the Chairman presented his case. As an electrical engineer he was in a position to make telling reference to the practice of charging in the electrical industry, with all its technique of " load factors," " off-peak loads," &c., &c.; but the parallel cannot be drawn as closely as is often supposed.

The Seasonal Differential Charging Scheme had for its main object to equalize to some extent the summer and winter loads, and to distribute the overhead charges in such a way that the periodical or seasonal consumers should carry their reasonable share of such charges, incidentally increasing the total demand. In general, where tariff schemes have been introduced, the service charge is made at a regular rate, whether monthly or quarterly, over the whole year, but the Author personally has some doubts as to the soundness of this principle, and holds the view that the service charge should be varied according to the seasonal demand. Is it not sound business practice to recover overhead charges during the period of maximum demand (one might almost say, compulsory demand), and to stimulate business by low prices during the time of minimum demand, in order to increase the total consumption and so reduce the amount of overhead charge per therm of gas sold?

To put it another way—is it not true that a fairly large fraction of the total expenditure is incurred to provide and maintain plant to meet the peak load? If so, there is nothing inequitable in recovering this fraction of the expenditure from the consumers during the period of maximum demand.

The undertaking, on the other hand, has no interest in increasing the consumption of gas taken by any consumer unless the increased quantity of gas can be supplied to that consumer without loss. Whenever a " two-part tariff " scheme is introduced the supplying authority must approach the consumers and show them that by the adoption of the scheme they will secure a reduction in the amount previously charged for a similar quantity of gas. Unless, therefore, there is an increase in the quantity of gas taken by the consumer his adoption of the two-part tariff scheme will reduce the amount of cash received by the undertaking for the same quantity of gas. But the advantages of the tariff scheme are not so great to the small consumer as they are to the good consumer. Therefore, the two-part tariff scheme, in itself, has the minimum of chances of converting the small consumer into a good one.

It would be interesting to learn what proportion of domestic consumers have, in fact, availed themselves of the two-part tariffs where these have been introduced. If, as the Author believes, the percentage is a small one, the increase in the aggregate demand will have only a very small effect in the reduction of overhead charges per therm for the whole quantity of gas sold.

Three objections to any two-part tariff scheme are, first, that the " fixed charge " is an arbitrary one, which it is never possible to establish to the satisfaction of all consumers; secondly, that the system is not easily understood by consumers; and, thirdly, that it must, of necessity, be optional.

For the scheme described in this Paper it is claimed that the scale of charges is independent of the considerations which must be taken into account in the calculation of fixed charges under any tariff system; the charges are set out in a price list, which is available to everybody and shews every consumer exactly what his account will be, without any calculation.

The system is based upon discounts, and it must be admitted that the popularity and success of the scheme are largely attributable to this simple fact.

In the case of the prepayment consumer who receives a rebate in cash when the meters are emptied, of 7½ per cent. in the winter and 50 per cent. in the summer, the system is not only greatly appreciated, but there is no doubt that it has served as a very strong weapon in resisting the attacks of electricity among this class of consumer which uses the rebate as a means of saving.

At the time when we were preparing for the new system the whole subject of gas charges was under intensive discussion in the Gas Industry, particularly during the opening months of 1928, and a great effort was being made to induce gas undertakings to adopt more " flexible and equitable systems of charging " than the flat rates which had generally prevailed in this country, and, generally speaking, although no definite recommendation was given, the conclusion was reached by the leaders of the industry, that, at all events as regards the domestic consumer, either a two-part rate consisting of a Fixed Service Charge covering those items in the cost which are unaffected by the variation in demand and a Commodity Charge covering all other costs in connection with the manufacture and supply of gas, or a Block System of charging, in which the charge made for the first block would include the service charge, would meet the case.

The main difficulty in applying the recommendation to Macclesfield was in the distribution of the service charge equitably among the consumers. It was found to represent, at all events in the case now reviewed, so large a proportion of the total cost that it could not be charged direct to existing consumers unless, and until, the demand had been increased to such a point that no appreciable increase in gross price would be felt by any large number of consumers. It was not disputed that the large consumer had been carrying too great a proportion of the overhead charges, and that the smaller consumer had been, to some extent, subsidized.

Equity, no doubt, demands that each consumer should bear his proportionate share of the overhead charges, but it was feared that such an ideal was out of our reach. As public utility undertakings we enjoy privileges that are not afforded to ordinary competitive businesses, and we are, I think, expected to give certain privileges to the consuming public for which we get no corresponding return. We are expected, in short, to " carry " a certain proportion of unremunerative consumers. But has not too much stress been laid on this point? In the first place, it would be interesting to know how many of the remunerative consumers to-day have been unremunerative in the past, and, in the second place, even if the so-called unremunerative consumers of to-day were cut off by imposing a high service charge, it would be found that a good proportion of the marginal cases would sink into the unremunerative class, and that this process, if re-

TABLE VII.—*Consumption of Gas per Consumer and per mile of main for Undertakings in Great Britain with annual makes of from* 400 *to* 500 *million C.Ft. for the years* 1933 *and* 1928.

See "Gas World Directory" for 1934 and 1929.

Number.	Year.	Annual Make in Millions of C.Ft.	Number of Consumers.	Consumption.		Population Served.
				Per Consumer, C.Ft.	Per Mile of Main, Millions of C.Ft.	
1	2	3	4	5		7
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1	1928	420	10,338	38,000	5·700	40,000
		+ 11·19	+ 26·16	− 10·53	− 8·42	+ 17·50
	1933	467	13,043	34,000	5·220	47,000
2	1928	529	16,479	29,032	4·535	59,000
		− 8·13	+ 9·16	− 13·10	− 13·91	+ 1·69
	1933	486	17,989	25,229	3·904	60,000
3	1928	448	12,255	34,109	5·225	60,000
		+ 5·13	+ 15·33	− 8·12	− 3·66	No change
	1933	471	14,135	31,340	5·034	60,000
4	1928	314	10,678	27,199	5·585	56,000
		+ 52·55	+ 95·88	− 24·33	− 35·25	+ 78·57
	1933	479	20,951	20,580	3·617	100,000
5	1928	415	12,334	29,600	6·091	54,350
		+ 14·22	+ 16·59	− 2·70	+ 4·73	+ 1·49
	1933	474	14,379	28,800	6·379	55,200
6	1928	348	10,029	29,838	5·547	50,000
		+ 29·31	+ 25·86	+ 8·65	− 22·08	+ 2·00
	1933	450	12,622	32,420	4·307	51,000
7	1928	431	16,458	24,200	5·238	55,000
		+ 3·48	+ 9·66	− 6·20	− 11·48	+ 18·18
	1933	446	18,048	22,700	4·637	65,000
8	1928	380	9,164	37,300	4·210	..
		+ 12·89	+ 45·74	− 24·02	− 26·67	
	1933	429	13,356	28,340	3·087	..
9	1928	515	14,946	31,305	5·705	50,000
		− 6·80	+ 3·58	− 10·01	− 6·78	No change
	1933	480	15,481	28,170	5·318	50,000
10	1928	362	9,634	34,668	5·302	40,210
		+ 20·72	+ 11·55	+ 1·53	+ 12·33	+ 8·18
	1933	437	10,747	35,200	5·956	43,500
11	1928	390	8,941	40,900	6·310	31,000
		+ 7·95	+ 8·86	− 5·38	− 2·90	+ 3·23
	1933	421	9,733	38,700	6·127	32,000
12	1928	411	11,796	32,315	4·887	83,000
		+ 10·71	+ 24·80	− 8·06	− 8·66	+ 2·41
	1933	455	14,723	29,710	4·464	85,000
13	1928	479	13,039	34,000	4·371	..
		+ 0·42	+ 14·98	− 10·00	− 9·52	
	1933	481	14,992	30,600	3·955	57,600
14	1928	376	9,654	35,700	3·676	..
		+ 22·08	+ 43·72	− 13·95	− 6·37	
	1933	459	13,875	30,720	3·442	59,100
15	1928	538	18,570	...	..	..
		− 24·35	+ 2·24			
	1933	407	18,985	18,270	2·504	..
16	1928	575	20,567	23,103	5·092	91,400
		− 17·39	+ 5·58	− 19·28	− 18·81	+ 0·66
	1933	475	21,715	18,650	4·134	92,000
17	1928	412	9,277	41,300	8·727	33,700
		+ 7·77	+ 16·90	+ 11·62	− 15·94	+ 9·79
	1933	444	10,844	46,100	7·336	37,000
Macclesfield	1928	355	10,011	33,750	6·368	33,846 (1921)
		+ 22·25	+ 8·38	+ 13·19	+ 16·41	+ 3·12
	1933	434	10,850	38,200	7·413	34,902 (1931)

peated, would continue until some of the best consumers had become hardly worth supplying.

CONCLUSION.

In conclusion, the Author submits that the figures put forward show clearly the effect of a more balanced and increased load in the reduction of standing charges per therm. The increased consumption per consumer directly reduces the distribution charges, and provided that the additional gas is sold at a price reasonably in excess of the average net cost of manufacture, no loss to the department can ensue.

In order to shew that an important increased consumption per consumer has been realized, Table VII. has been prepared from the 1934 edition of the "Gas World" Directory, comparing the 1933 figures for the whole of the undertakings with annual consumptions more than 400 and less than 500 million cubic feet, including Macclesfield, under the headings Annual Make, Number of Consumers, and Consumption per Consumer and per Mile of Main, with those for 1928. Another column has been added shewing the increases in the population between the years 1928-1933, as far as these are given or known. It will be seen that the increase in consumption per consumer for Macclesfield is over 13 per cent. as compared with the next highest 11·62 per cent., and that out of the nineteen examples of undertakings of this capacity only four shew increases at all in this figure.

The advantages of the Seasonal Differential Charging System may be summed up as follows:—

(1) The system is so simple in its form that everyone can understand it.
(2) No arbitrary assessment, as in the two-part tariffs, is necessary.
(3) It is expressed in the form of a discount, which is paid to the consumer in a lump sum when meters are cleared or bills are paid.
(4) It stimulates demand during the months when consumption naturally languishes.
(5) It encourages the purchase of apparatus in the summer, the use of which is largely continued in the winter.
(6) It levels up the seasonal load, while increasing the annual demand, thereby reducing the overhead charges per therm.
(7) It does not entail any alterations to prepayment meters when changes are made in the rate of discount, which are virtually changes in gas-charges.
(8) The system being applied to all consumers eliminates the possibility of invidious comparison between one class of consumer and another.

Modernizing Small Gas Undertakings

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In view of the interest in small Gas Undertakings which has been aroused during recent years it is felt that a Paper dealing exclusively with these may not be out of place. There has been a general desire to improve the efficiency of the small concerns so that they may be brought nearer the high standard which is the aim of the Industry as a whole. With the fierce competition of the electricity grid and oil burning domestic apparatus, many of the small companies will go under unless obsolete plant is brought up to date.

It is usually lack of capital rather than the lack of desire that prevents improvement, and when this is the case, the difficulty may often be solved by purchasing a bulk supply from a large neighbouring works or by the Company becoming a subsidiary of one of the Corporations formed to control small Undertakings. In the first case, the works are usually shut down and the gas supplied from the larger works, either into the holders or direct to the district, so that it is only the district mains that have to be put in order; in the second case, money must be spent on both the works and district. It will be realized that the proper financing of these small Undertakings is only possible where capital is available and immediate return is not essential.

NEW CARBONIZING PLANTS.

It sometimes happens when reconstruction is required on the Works of a small Gas Undertaking that a complete new carbonizing plant is justified. Perhaps the existing retort bench and retort house itself are in exceptionally bad condition or there is no room for extension; the site may be undesirable or the Undertaking may have grown to such an extent that a more up-to-date type of plant is needed. When this is the case, there is an opportunity which does not often occur for introducing modern or experimental plant adapted to suit the needs of the small works.

Much pioneer work has been done in recent years by the manufacturers of continuous vertical retorts, who have shewn that this type of plant under certain conditions is admirably suited for small Undertakings. There is considerable scope however for new ideas, particularly in the very small places where the capital cost must be considered in hundreds of pounds instead of thousands, and where the plant can have but little supervision.

Individual circumstances alone can dictate the type of plant to be used, but the size of the Undertaking must have a strong bearing on it. A description is given in this section of some new carbonizing plants which have been erected in works under the control of the British Gas Light Company and the circumstances which influenced their selection.

In the smallest works, where the number of men employed is small, the new plant may not shew a great saving in labour costs—the improvement being effected in making the work easier—but on the larger works substantial labour economies can often be effected.

(*a*) A 17 Million Cubic Feet Works; Small Inclined Retorts.

The Baldock Gas Light and Coke Company has an annual output of about 17 million cu.ft., and when control was taken by the British Gas Light Company the carbonizing plant, consisting of three beds of horizontal retorts, was inadequate and very old. In order to meet the peak load, excessive heats had to be worked and the charges rushed through in from four to six hours. There was not room in the retort house for extension of the retort bench, and the position of the house was such that to extend it in either direction would have been an awkward and costly procedure. In addition, the retort house was itself in bad condition. It was therefore decided in 1930 to erect a completely new carbonizing plant on another site.

Very careful consideration was given to the claims of the vertical type of plant, but the initial cost was high for a Works of this size. The suggestion was put forward that the inclined retort, although generally considered defunct, would make a very suitable type of plant for this size of Works. It need be very little bigger than a stop-ended horizontal installation, and yet with a suitable type of coal, a much fuller charge could be put in than was possible by hand-charging, while discharging would be nearly, if not quite, self-operating by gravity. Two firms of contractors were approached with regard to the construction of such a plant, and both expressed their confidence that the scheme would work well.

It was decided to make the experiment and tenders were accordingly obtained, the order being eventually placed with Gibbons Bros., Ltd. Inquiries concerning, and inspection of, inclined retorts still in operation had revealed only one obvious difficulty, and that was in the filling of the fires. In the larger size of inclined plant, one stoker checks the descent of the charge with a rake while another feeds the coke through the chute into the fire, but this would not be possible at Baldock, where it was essential that the labour should be limited to one man per shift. However this difficulty could be overcome by having a furnace feeder cart big enough to contain the whole charge, so that the retorts could first be recharged and closed and the fire then replenished from the furnace feeder cart.

Work commenced on the erection of the plant in April, 1930, and it was put to work in December, 1930.

The retorts are fireclay, 12 feet in length, D section, tapering from 21 in. by 15 in. to 23 in. by 15 in., and set at an angle of 32 degrees to the horizontal. There are three main arches, the first having a setting of six retorts, the second four retorts and the third being left empty in preparation for another setting when the consumption grows. The regenerators are 7 ft. 6 in. deep, so as to give full regeneration, and the producers, which are fitted with step-grates, are projected forward by three feet so as to give ease of filling. The combustion chamber is divided into two sections, with separate feeds for the CO and secondary air to the upper and lower sections. Independent hydraulic mains are provided for each setting, and these are connected to a tar tower. The foul main is 10 in. in diameter and fitted with a 6 in. retort house governor.

For coal handling, there is a continuous range of hoppers, each compartment having a capacity of 5 tons, the bottom outlet being fitted with slides operated by long levers. The retorts are filled by three separate travelling chutes, one for each tier, with a hinged plate at the bottom to rest on the mouth of the retort. (In future plants a single chute with three outlets would probably be more convenient.) The coal is elevated to the hoppers by a continuous bucket elevator from which it is fed to a belt conveyor running above the hoppers. The elevator and conveyor are geared together and driven from a single 5-h.p. Marshall vertical steam engine. Coal is diverted from the belt into any hopper by trippers operated from the stage floor.

For the coke discharge, chutes are provided in the lower stage floor so that the coke falls straight through into barrows on the ground floor level. Quenching sprays are fitted below the stage floor opposite the chutes, the water being supplied from a tank at the top of the house, and the hot coke is quenched in the barrows.

The retort house itself is a steel framed building with brick filling, having a stage at discharge level and another at charging level. One gable end has been left open to provide for future extension and has been covered

with asbestos sheets. There are large openings in the retort house wall on the discharge side, and these are fitted with roller blinds for use in winter.

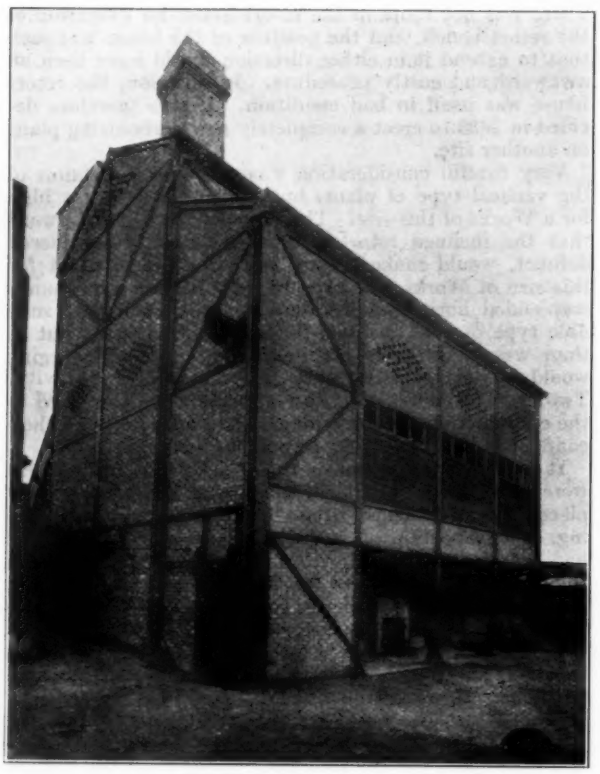


PLATE 1.—*Front View of Retort House, Inclined Retorts, Baldock.*

A test run was made on the bed of six retorts some little while after the plant was put to work, the following results being obtained using Yorkshire coal (Wombwell washed nuts):

Therms per ton	75 (at approx. 480 B.Th.U. C.V.)
Coke made for sale . . .	10 cwts.

It is difficult, owing to the absence of a recording calorimeter, to give accurate results over a continuous period, but it is safe to say that the therms made per ton are not less than 72.

Repairs during the three years in which the plant has been at work have cost a total of £51, £48 of which was spent on relining producers and patching retorts. In addition, it was found that the plates of the furnace feeder cart, which was constructed of steel, buckled badly, and it was necessary to fit a cast iron lining and door. In this form it is quite satisfactory.

The contract price of the complete plant, including foundations, was £4,285.

This plant has demonstrated that the inclined retort is a practical proposition for the small Works, although it has not had a chance to show the full economies that could be achieved, as the consumption of gas at Baldock has not grown to the extent anticipated. If the third arch were in use, the plant could still be worked with one stoker per shift. Coke figures have been adversely affected by the necessity of leaving charges in or of reducing the number of charges to two per diem.

The coal runs easily and evenly into the retort, and the weight of charge is about 5 cwts. Discharging at first required no assistance, but later on it was found that the top retorts required a little poking. The general work however of charging and discharging is extremely light when compared with stop-ended horizontals.

(*b*) A 3½ Million Cubic Feet Works; A Modern Direct-fired Retort House.

Eynsham, Oxfordshire, one of the smallest Stations of the British Gas Light Company, when first purchased had an output of only 2½ million cu.ft. per annum. Not only was the carbonizing plant badly in need of repair, but the retort house itself was collapsing and the roof had been strutted to the bench brickwork. There was much water just below the surface of the ground, and the cellar of a generator setting was constantly full.

To repair the house and plant would have cost not far short of £1,000 and would have been difficult. Accordingly, the cost of a new retort house was investigated, and this in so small a place had to be kept extremely low, particularly as other heavy expenses had been incurred, including a new holder.

With a Works as small as Eynsham, where the retorts are not charged at night, it is questionable whether the additional coke made for sale is worth the extra expense of a generator setting, and certainly not of a regenerator. With an up-to-date direct-fired setting, some attempt at regeneration can be incorporated, and quotations for a simple yet modern house on these lines were obtained, and an order was placed with Gibbons Bros., Ltd.

The new bench consists of two settings, one of four retorts and one of three. The retorts are moulded fireclay, 21 in. by 15 in. by 9 ft., D Section. The furnaces are taken to a depth of 1 ft. 9 in. below the ground level so as to obtain as much fuel depth as possible, and also to obtain room for a short length of secondary air flue, the air being admitted into the producer just below the bottom retorts. Some slight preheating of the secondary air is obtained by bringing the waste gas down to a flue alongside the secondary air and then taking it up again to an overhead main flue. In order to obtain access to these flues and the dampers, the floor is excavated in front of the furnace and covered by removable steel plates. The furnaces are fitted with the ordinary bar grate. The chimney, which comes off the bench at the end of the main flue, is 16 ft. high and 1 ft. 6 in. square (internal). Separate steel hydraulic mains with bottoms sloping to a central tar run-off are provided and situated well above the beds. The tar run-offs are connected by a 4 in. main to a tar tower, which is 10 ft. by 1 ft. 6 in.

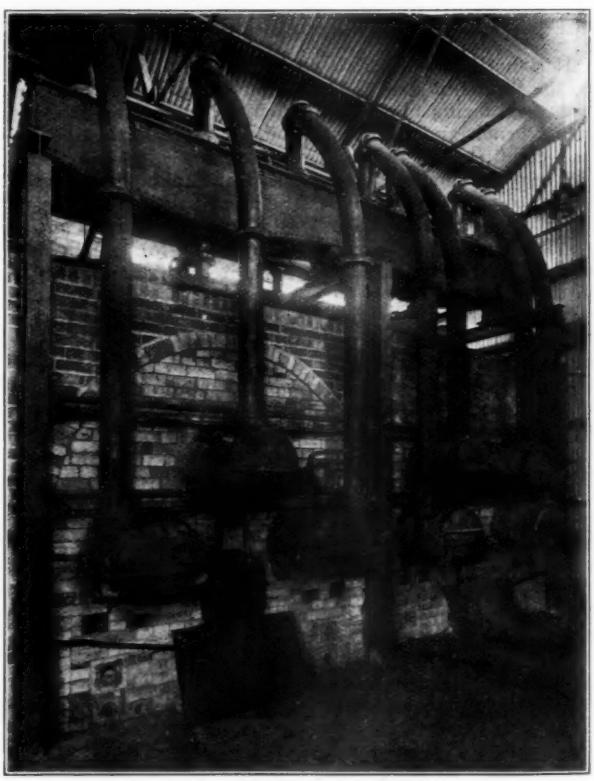


PLATE 2.—*Retort Bench, Direct-fired House, Eynsham.*

by 12 in., and has a branch from the tar outlet taken through the retort house wall so that barrels can be loaded direct from it. The retort mouthpieces are fitted

with self-sealing lids, and are braced with single lines of 5 in. by 2½ in. bulb rail. Ascension pipes are 6 in. in diameter.

The foul main is 8 in. in diameter, and is taken round the house and thence along the outside of the back wall. With this arrangement, a condenser is not really necessary, and the plant worked for a long time without one. When the old retort house was pulled down the existing condenser was moved across to the new house.

The retort house is a plain brick building with an asbestos cement sheeted roof and ventilator. In order to provide for future extension, one end wall has been left out and light steel framing and asbestos sheets substituted.

The complete house was erected in a space of six months, and cost £1,195, including foundations.

(c) 105 Million Cubic Feet Works; Through Horizontal Retorts with Congdon Pipes.

At the King's Lynn Works, there is, for this size Works, an exceptionally large retort house, which measures 117 ft. by 59 ft., and is proportionately lofty. In this house, in 1931, there was a retort bench comprising the very unusual arrangement of five horizontal regenerator settings in three arches. One of these arches contained "through" retorts 20 ft. long, while in each of the others there were two settings of 10 ft. stop-end retorts back to back. The retorts were charged by a small suspended de Brouwer projector machine and discharged by hand. This plant occupied but one-half of the retort house, the remainder being used as a coal store. The coal gas was augmented with carburetted water gas.

The retort beds needed considerable repairs, but the output had grown to a figure at which it was not economical to continue to work stop-ended retorts, and plans were put in hand for new plant.

With so spacious a retort house, there was no question of a new site for carbonizing plant, even had it been available. Vertical retorts of both continuous and intermittent type were considered, but in either case it would have been necessary to raise the roof—an expensive procedure—and the capital cost would have been in the neighbourhood of £15,000. In addition, subways were already available, which would serve part of a horizontal installation. Eventually a simple scheme was proposed in which two beds of horizontal retorts would be built in the space beyond the existing chimney and connected to the chimney. A larger stoking machine would be installed and the plant put to work. During the summer months, the old beds would be dismantled and two further new beds erected on the existing foundations. The electric current hitherto used on the Works had been the town supply of 400 volts direct current. It was decided that the new stoking machine should have its own generating plant, in the first place to be independent of the town supply, secondly because a change over to alternating current was probable, and thirdly because it would be cheaper.

About the same time the Congdon system of stand pipes had been installed at a number of works in place of the normal ascension pipes, and as a result of inspection and recommendation, it was arranged that the new bench should be fitted with this system.

The scheme was put in hand and tenders obtained. Gibbons Bros., Ltd., were entrusted with the two beds and Congdon system, and Aldridge and Ranken, Ltd., with the stoking machine and generating plant.

The two new beds consisted each of six 20-ft. silicious moulded retorts, 24 in. by 18 in., D Section. The 20-ft. length was adopted in order that the existing subways serving the back to back benches might continue to be used. Centre screw type mouthpieces were fitted, those on the discharge side being the shallow type.

The existing subways were extended for the length of the new bench and joined together beyond the end wall. The subways, however, were not wide enough to accommodate the separating tank into which the tar and liquor from the Congdon scrubber pipes usually run. A good deal of thought had to be given to this question of liquor circulation for the stand pipes, as it would have to deal eventually with the four beds. A special section of subway could have been constructed, but, apart from the expense, it was desired, if possible, to avoid the additional pumping from this tank to the yard liquor tank. It was eventually decided, after consultation with experts, to circulate direct from the yard tank, which is of about 15,000 gallons capacity, provided the condensate from the condenser seal pot were run into the return pipe from the Congdon system, so as to make up the loss of liquor from evaporation. This was accordingly done, and has proved completely successful.

Stoking Plant.

The stoking machine is a Fiddes-Aldridge Multi-Stroke, which is a type not quite so well known as the large "F.A.," but very suitable for small works. It performs the charging in three shots. On the return from the first shot, the pusher plate at the head of the scoop lifts to a horizontal position and remains thus for the remaining shots. The machine is fitted with a single motor of 12 H.P., which is an advantage for a small works, and the hoisting, travelling, and charging gears are engaged by a system of clutches. The average weight of charge is 15 cwts. with washed doubles (Yorkshire coal).

The generating plant consists of a Sissons high-speed engine driving a 10-KW. D.C. generator. This is probably, at the moment, the smallest generating set in use with a stoking machine, and it stands up to the work remarkably well. The coal elevator and the coke plant are run from the town supply in order to avoid the necessity of starting up the generator.

It is not deemed necessary on a works of this size to have an elaborate coke handling plant, as the quantity of coke is not great and the capital cost of mechanical plant is high. At King's Lynn a mono-rail track, from which is suspended a hand propelled skip holding 12 cwts., runs in front of the bench and from there into the coke storage yard via a quenching tower. The quenching tower was found necessary to keep steam from blowing into the roadway close to the retort house. In putting up this track, it was found possible to incorporate the track of the old suspended charging machine and this helped to reduce the cost.

Coal Plant.

For coal handling, the existing coal hopper and elevator were re-erected in a new position over the machine; the elevator had to be lengthened by 11 ft. This work was done by the Works Engineer with his own staff.

There is no coal storage space in the yard between the road and the retort house, and it was found convenient to have the elevator inside the house. The light lorry, which carts the coal, backs into the retort house and the driver starts up the elevator and feeds the coal straight up into the hopper (12 tons capacity). There is no railway siding at the Works and coal is carted from the railway station daily, but with this arrangement there is very little double handling after coal is unloaded. This also gives some idea of the spaciousness of the retort house.

The plant was completed in February, 1932, and found to be very successful with a big saving in labour and other manufacturing costs. In consequence, a quotation was obtained for two further beds, and these were erected according to programme on the foundations of the old plant.

The total cost of the contract was £9,239, and the Company's own work cost approximately £200.

With each bed, 115,000 cu.ft. of gas is made, and the maximum day of 440,000 cu.ft. can be met with four beds and a little water gas, or three beds and a larger percentage of water gas. The Congdon stand pipes have fulfilled the claim for the absence of stopped pipes, and, in addition, the complication of hydraulic mains, dip pipes, and seals is dispensed with.

Results Obtained.

In operating these beds with Congdon pipes, a high quality coal gas (570-590 B.Th.U.) is made, and this is

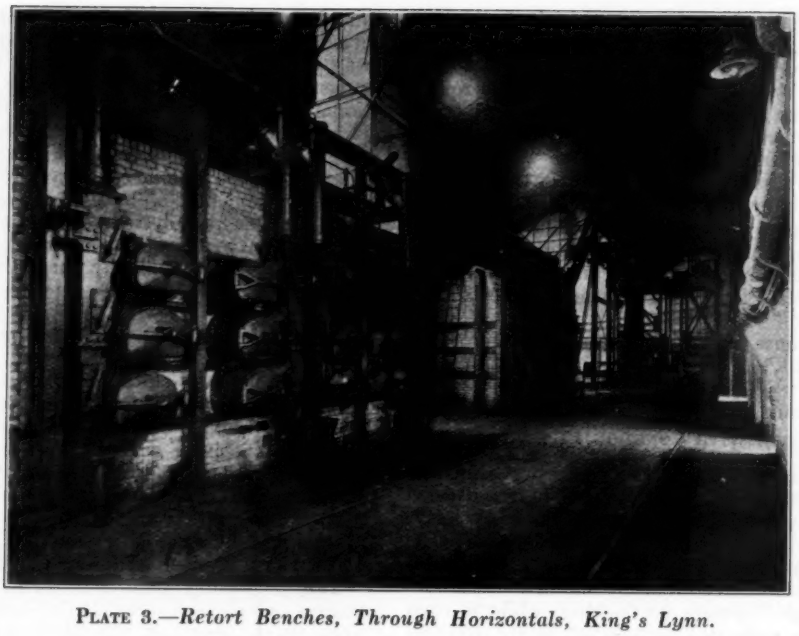


PLATE 3.—*Retort Benches, Through Horizontals, King's Lynn.*

then diluted with blue water gas to the outlet calorific value of 500 B.Th.U., this giving a considerable saving in oil.

Previous to the alterations, seven to ten stokers were employed in the retort house and operating the water gas plant. With the new plant, five stokers are employed for the same duties. Three of these stokers are machine drivers, and on the morning and afternoon shifts they also operate the water gas plant which is not operated at night. The other stokers attend to the boiler and certain other duties.

TABLE I.—*Comparison between the Old and New Plants at King's Lynn, using Yorkshire Coals.*

—	1930.	1933.
Make per ton—Coal gas, cu.ft.	14,000	12,473 cu.ft.
" " " —Coal gas, therms	70	72·28 therms
Coal gas—Calorific value	500	579·5 B.Th.U.
Coke made—Make per ton	13·11	13·7 cwts.
Coke made for sale	9·11	10·9 cwts.
Fuel figure in producers	20	14 per cent.
Oil used	52,000 galls.	No oil used
Carbonizing and water gas plant—		
Wages per 1,000 cu.ft.	3·586	2·026 pence
Cost into holder per 1,000 cu.ft.	1s. 10d.	1s. 7d.

(*d*) A 95 MILLION CUBIC FEET WORKS; KLÖNNE INTERMITTENT VERTICAL CHAMBER OVENS.

The Westgate and Birchington Gas and Electricity Company became a subsidiary of the British Gas Light Company, Ltd., in May, 1929, and it was soon obvious that the carbonizing plant was inadequate to meet the needs of two growing seaside resorts. From 1906 to 1931 the consumption of gas had increased from 38,351,000 cu.ft. to 91,077,000 cu.ft., and the district is still growing.

The large and substantial retort house contained six settings of six stop-ended retorts charged by a West's manual charging machine, which incidentally was one of the few remaining machines of this type in the country. The Company was using Kent (Chislet) coal, and the plant with this coal had a maximum daily output of 220,000 cu.ft. when operating on 6-hour charges with three stokers per shift. With the addition of 35 per cent. carburetted water gas the works was just able to meet the maximum day of 341,000 cu.ft. Apart from this inadequate capacity, the carbonizing plant was uneconomical to operate, both from the point of view of labour and of results, and so new plant had to be considered quickly.

Owing to the proximity of the Chislet Colliery and the reasonable price of the coal, it was very desirable that this coal (although not first-class gas-making) should continue to be used, and the new plant had to be selected with this in view. A price was obtained for an installation of through horizontal retorts, complete with stoking machine, electric generating plant, coke conveyor and coke hopper. This would have involved a stage type house built as an extension to the existing house, and the price was to have been £18,901.

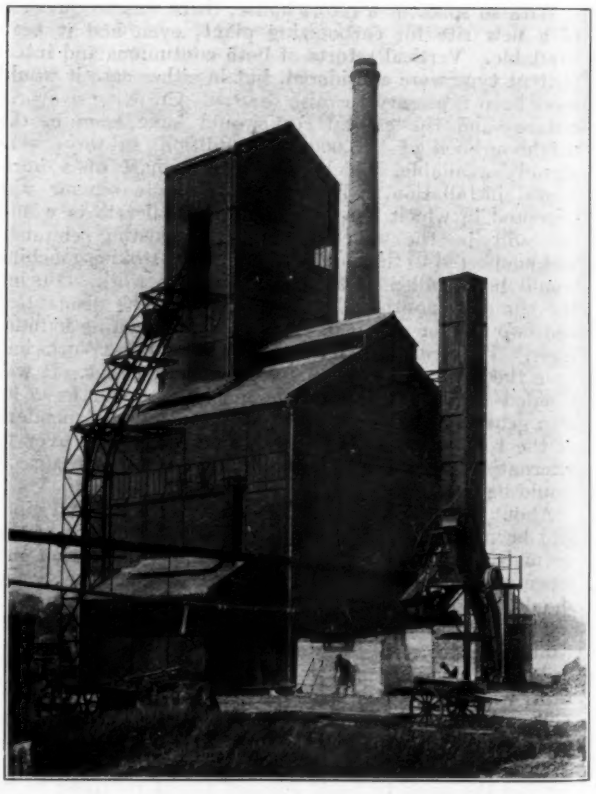


PLATE 4.—*General View, Intermittent Chamber Ovens, Westgate.*

In the meantime, while this plant was under consideration, intermittent vertical chamber ovens were coming into prominence through one or two large plants being erected in this country. At the same time an opportunity was presented of inspecting, on the Continent, chamber

ovens constructed by the well-known firm of Aug. Klönne, the English construction rights for which had been obtained by W. J. Jenkins and Co., Ltd., of Retford. One of these installations was in operation on a small works in Germany, and at once suggested the suitability of this type for works of the size of Westgate, or even less. The intermittent oven is not limited to particular types of coal, as with the continuous verticals, and therefore would operate with Kent coal, and it also promised high thermal yield, minimum labour, flexibility, low maintenance cost and absence of continuously operating mechanical plant. Accordingly competitive tenders were obtained for intermittent chamber ovens, and that of W. J. Jenkins and Co., Ltd., for a Klönne type plant was accepted.

Work on the foundations, which were constructed by Messrs. J. L. Keir, sub-contractors, commenced on the 18th September, 1931, and the first oven was charged on 23rd March, 1932. The old horizontal house was shut down on the following day.

[An account of the plant follows. A description was given in the " JOURNAL " for July 13, 1932.]

Results Obtained.

Since the plant went to work, six chambers have been continuously in operation, and these have worked on schedules varying from 24 hours to 14 hours, according to the load. The plant could be operated entirely by one stoker per shift, but it is found in practice to be more convenient to have two men, who divide their duties between the plant and coal and coke handling. With this arrangement both men are on the plant at the time of charging and discharging, which greatly shortens that operation.

The Klönne plant has been found entirely satisfactory in operation and to require a minimum of attention and work. Its flexibility has been a decided advantage. The coke is a definite improvement on the coke from the horizontals. During the two years in which the plant has been at work, the offtake pipes, both top and bottom, have been perfectly clean. Wire baskets were fitted into the hydraulic mains to catch pitch, but practically none is forthcoming. The water content of the tar is under 5 per cent.

In Table II. are appended some results which have been obtained from the intermittent vertical chamber ovens compared with those obtained in the old plant.

TABLE II.—*Comparison between Old and New Plants at Westgate.*

—	Old Plant. 1931	New Plant. 1933.
Make per ton—Mixed gas	..	15,169
,, ,, ,, —Coal gas	10,827	..
Calorific value	537	500
Therms per ton	58·21	75·84
Coke and breeze made for sale	7·6	10·75 cwts.
Cost per 1,000 cu.ft. into holder	2s. 2d.	1s. 8d.

RECONSTRUCTION OF WORKS.

(*a*) CARBONIZING PLANTS.

It is rare when a small Works is taken over to find the carbonizing plant in a sufficiently good state of repair or well enough equipped to continue to work as it is. To many a Manager's disappointment, however, only occasionally is a completely new carbonizing plant justified, and instead some means must be found of bringing the existing plant up-to-date with as moderate expenditure as possible.

Usually the first part of the plant to call for attention has been the hydraulic mains, as these are often out of level and not fitted with any proper form of tar run-off. Frequently they are supported directly from the bench brickwork, and it is impossible to tell the depths of the seals, while an accumulation of tar has caused the bottoms to be pitched up.

In the second place, it is often found that inadequate bracing or corrosion of buckstays has caused the bench to move, with the consequent falling of arches, bulging of back walls, and other troubles. Under these conditions, money spent on resetting is wasted until the bench has been properly braced.

Thirdly, improvement can often be made by converting direct-fired settings to generator or regenerator settings and replacing luted lids with the up-to-date luteless pattern.

Halstead.

One of the worst examples of a bench which was both in a dangerous state and with hydraulic mains in bad condition was at Halstead, Essex (35 million cu.ft. per annum).

The bench of four settings of 10-ft. stop-ended retorts, erected in 1899, had been built on waterlogged ground, and suffered from vibration caused by a metal breaker in a foundry adjoining the retort house. It was not strongly braced, and all the arches had been extended forward and two settings converted from direct-fired to generator type without underpinning of the arches or additional bracing. Six tie rods had been taken through the main flue, and in consequence had long ceased to do duty as such, while three buckstays had corroded away at floor level. As a result the arches had all dropped and the end walls were splayed out. In the case of the end bed, there was a difference of more than 5 in. in height between the centre of the arches and their ends.

The ironwork had been obtained second-hand many years previously, and the hydraulic mains, which were supported from the brickwork, were flat-bottomed, out of level and very thin.

Resetting was urgently required to two beds, but it was obvious that this could not be undertaken until the bench was made safe. To do this, it was arranged that the bench should be firmly held together with new strong bracing. Nine additional 12 in. by 5 in. buckstays were fitted in front of the existing buckstays, five for the front and four for the back, and two 12 in. by 6 in. buckstays for the end walls. Double lines of cross and longitudinal 1½ in. tie rods were fitted. Two hydraulic mains of more recent design were provided from another of the Company's Stations and supported on brackets from the buckstays. A tar tower, gas valves, tar valves, bridge pipes and dip pipes were also supplied from this Station, and two beds were fitted up with new ironwork and connected to the tar tower.

When the two end settings were pulled out to be reset, the arches collapsed still further, as had been anticipated. Both arches were completely rebuilt, careful strutting of the buttress walls being necessary while this was being done. This work cost £925. Later on the ironwork of the remaining two beds was put in order, and two more arches are being rebuilt.

Petworth.

At another Works, Petworth, Sussex (5 million cu.ft. per annum), with a carbonizing plant of three settings, the buckstays were of light section and had corroded away. The longitudinal ties had broken off from the buckstays, and the cross-ties passed through the chimney and the bench required properly bracing. The bench was very close to the side and end walls of the retort house, and the intervening space had been filled in with rubble so that movement of the back wall of the bench had caused a bulge in the retort house wall, which incidentally was always hot.

To overcome this trouble, it was decided to place six 10 in. by 6 in. vertical joists outside the retort house, four against the side wall and two against the end wall. The débris between the walls and the back wall of the bench was cleared out as far as possible and three rows of 6 in. by 5 in. horizontal members were fixed at the back of the bench. The space was then filled in with an 8 and 1 brick and cement mixture. Four 10 in. by 6 in. buckstays were fitted in front of the bench and two more at the other end of the bench, inside the house.

Instead of cross tie rods, 6 in. by 5 in. joists were fixed across the heads of the buckstays. The hydraulic mains, which had hitherto been supported on the brickwork, together with the foul main, were hung from these joists. The end buckstays were tied by means of 1¾ in. tie rods. The chimney is built on the bench in the line

of one of these tie rods, and it was necessary to have the rod in two sections, each connected to a frame built round the chimney.

Apart from the hydraulic mains being out of level, there were no tar run-offs, except in the centre bed, the tar and liquor running over seal control valves to the foul main. A tar tower was installed, new tar outlets were cut in the hydraulic main, tar valves fitted and a new 4 in. tar main run. The cost of this work was £250.

These two instances have been quoted as beds in unusually bad condition, where both the top ironwork and the bracing have been at fault. It more often occurs that only the hydraulic main and tar system need overhauling. These appurtenances may not necessarily be in a state of bad repair, but frequently it is found that the beds in a bench have varied types of hydraulic mains, valves and run-offs (if any), and that the hydraulic mains are at entirely different levels. It is the policy

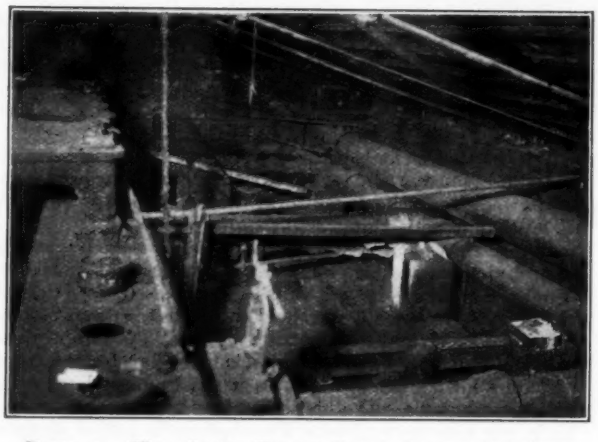


PLATE 5.—*Warminster Retort Bench Ironwork before Alteration.*

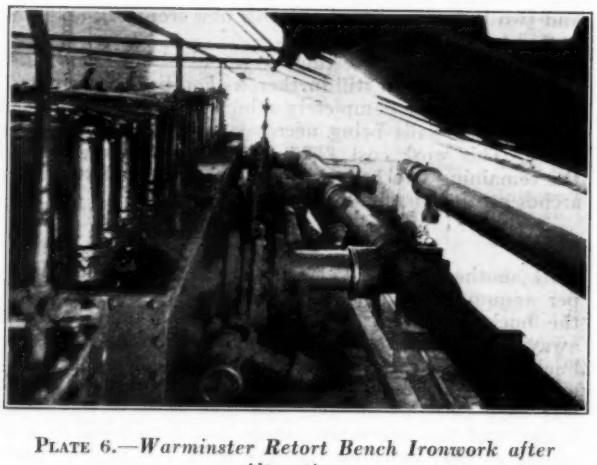


PLATE 6.—*Warminster Retort Bench Ironwork after Alteration.*

of the British Gas Light Company, whenever possible, to level the hydraulic mains and to install a tar tower so as to have proper control of the seals. Naturally, the cost of this rearrangement depends on so many factors that standard costs cannot be given, but in the worst cases they may vary from £100 for three small beds to £200 for five larger beds of stop-ended retorts.

Plates 5 and 6 above shew a typical example of the top ironwork of a bench before and after alteration. The illustrations were taken at Warminster, Wilts. (28 million cu.ft. per annum).

Conversion of Beds.

On many works equipped with direct-fired beds, except the very smallest, when the time has come for resetting, it has been politic to convert them to generator or regenerator settings. With Stations up to about 25 millions the conversion is usually to the generator type with a small cellar reached by a ladder from the charging floor. Two sample costs are given:—

Bed of five stop-ended retorts—9 ft. by 21 in. by 15 in. £319
" " " " " —9 ft. 3 in. by 21 in. by 15 in., complete with new mouthpieces and including underpinning £348

For works above 25 million cu.ft., settings would usually be converted to the regenerator type, and this is naturally more expensive. For a bed of six 10-ft. stop-ended retorts the price would be in the neighbourhood of £750, or £675 if the pier walls are not taken down to the subway level.

At Maldon, Essex, a shallow generator setting of eight retorts was rebuilt as a modern regenerator setting of seven retorts, 10 ft. by 22 in. by 16 in., complete with new ironwork. This, with the necessary underpinning, excavation (including the removal of some very hard concrete foundations), the construction of subway and laying of new foundations cost £720.

For small works, step-grates have been found to be very successful.

(*b*) Coal Gas Dilution.

Means of reducing the calorific value of the coal gas at small Works, other than by the usual methods of drawing in air or over-pulling on the retorts, are being investigated. For the larger of the "small" Works, water gas plants are available, but for the smaller, apparatus that does not require constant operation is desirable. At one Works a small suction gas "plant" is used. This consists of a firebrick lined cast iron vessel, 2 ft. 6 in. by 3 ft. 6 in., filled with incandescent coke, in the base of which air and steam are admitted. The resultant gas is taken through a 3 in. pipe direct into the foul main, and consequently the pull of the exhauster is constantly on the apparatus. Beyond replenishing the fuel, no attention is required, and the mixed gas (with Yorkshire coal) is about 17,000 cu.ft. per ton at 450 C.V.

At Fenny Stratford, Bucks, a successful experiment has been made with producer gas dilution. At this Works

TABLE III.—*Results before and after Diluting with Producer Gas.*

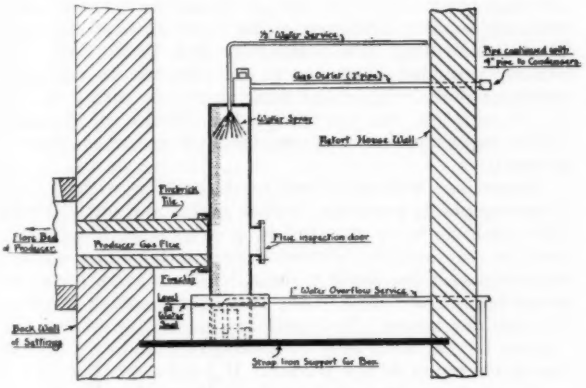
—	Method of Dilution.	
	Overpulling and Excess of Air.	Producer Gas.
Average make per ton	14,300	15,400
Calorific value	469	471
Therms per ton	67	72·4
Fuel consumption—Cwts. per ton coal	3·2	3·5
Typical Mixed Gas Analysis.		
Per Cent.	Nov. 2nd, 1932.	June 12th, 1933.
CO_2	4·0	3·3
O_2	1·4	0·6
C_nH_m	2·6	2·6
CO	6·0	10·3
CH_4	27·5	27·4
H_2	33·9	33·0
N_2	24·6	22·8
Total	100·0	100·0
Calc. specific gravity	0·5724	0·5773
Typical Producer Gas Analysis.		
Per Cent.	No Steam on Producers. Oct. 13th, 1933.	Exhaust Steam on Producers. Nov. 4th, 1933.
CO_2	6·6	6·0
CO	23·9	25·6
H_2	11·9	13·6
N_2	57·6	54·8
Total	100·0	100·0
Calorific value	114·5	125·2

there are five regenerator settings of 10 ft. stop-ended retorts, four of which have horizontal bar grates; three of these beds are at work in the winter. The producer gas was taken from the flare bed at the back of the pro-

ducer by 2 in. wrought iron pipes and connected to the gas main at the inlet of condenser. Some quite good results were obtained, but trouble was experienced with the overheating of the pipes at the offtakes, which burnt out after ten days' work, and also with choking up with dust in the service. The producer gas was very hot when it entered the condensers.

Eventually a successful offtake box, forming a combined cooler and dust collector, was designed by a member of the Engineering Staff, who conducted the experiments. The inlet is in the centre of the box, and the actual connection into the flare bed is by a firebrick flue. The outlet is at the top of the box, and just beneath it is a water spray which both cools the gas and washes from it a large percentage of the flue dust. There is a water-sealed tray at the bottom of the box, with an 8 in. seal, and the dust falls into this, forming sludge, which is periodically raked out. It was found that much better results could be obtained by using 4 in. pipe for the service, and this was fitted, using crosses and tees to facilitate cleaning. The box is illustrated in Figure 1.

Exhaust steam was introduced into the producers, and the hydrogen content of the producer gas thereby considerably increased.



PRODUCER GAS COOLING BOX AND OFFTAKE

FIGURE 1.—*Section of Producer Gas Offtake Box.*

At Fenny Stratford the hydraulic mains and dip pipes are not level, and instead of re-levelling them, an experiment has been made in working unsealed. This has been found to be quite satisfactory, provided the retort house governor is kept cleaned and in good working order.

At the same time, liquor circulation was introduced primarily to reduce the quantity of liquor running to waste. Liquor is sprayed into each dip pipe, whence it flows with the tar to the tar tower; the liquor overflow from the tower runs back to the circulating tank.

(*c*) WORKS PLANT RECONSTRUCTION.

One advantage of the grouping of small Undertakings under one control is that plant lying idle at any Works can be transferred to another Works where it will be of service. At the Chief Office of the British Gas Light Company, a register of surplus plant at all Stations is kept, and when reconstruction at a Station is in progress it often happens that the expense of purchasing new plant can thus be avoided. When a Works is supplied with gas in bulk and consequently shut down, much plant (some of it perhaps in almost new condition) becomes idle, and it has been found that within the space of about three years nearly all of it can be utilized.

When a Works has been taken over, it has frequently been found that the exhauster house is one of the most neglected sections. There has been perhaps only one exhausting set, and that has run for years with such reliability—although loudly protesting—that it is rarely looked at. If there has been a spare set, it is most unlikely that it would start up if required, and is even less likely to remain running. The building itself is often completely dilapidated, and in many cases serves also as a fitting shop, which results in its being much littered up.

Washing plant often consists only of a tower scrubber, and this has frequently not been cleaned out for many years.

It is sometimes found that purifiers, even if in good condition, are so arranged that the order of the boxes cannot be changed, and these also may be of insufficient capacity. At Eynsham, Oxfordshire, the purifiers consisted of two 6-ft. waterlute boxes which had been "home-made" with concrete. The boxes had cracked and were strapped up as well as possible, but were always in imminent danger of collapse. The valves were in very bad condition so that it was not known which way the gas was travelling, but most of it must have been passing along the main between the boxes without going into either. In an endeavour to overcome the trouble, the Manager had to change a box each day. Two 6-ft. cast iron boxes with connections were transferred from Aldeburgh, Suffolk, and were installed in their place, and the Manager's anxiety has in consequence been allayed.

Rarely is there any idea of the accuracy of the station meter, and there is equal doubt as to the identity of its manufacturer. It has been found expedient at several Works to combine repairs with an increase in capacity of the meter, by having the drum rebuilt for higher speed with a large centre opening.

Holders have frequently been heavily patched in an endeavour to keep the leakage down, and some more drastic repair is required. Painting has often had to be postponed for financial reasons.

Station governors, though of old pattern, may continue to work well. Some Undertakings, however, have no governor, and when this is so—except at the smallest Works where the holder throws no more than 4 in.—a governor has been put in so that a regular pressure can be kept on the district. At two Undertakings, pressure-loaded governors have been installed because they have the advantage of being totally enclosed.

Sometimes a Works equipped with fairly good plant has been allowed to fall into a state of complete neglect, and by some rearrangement and reconditioning of the plant, together with alterations to the buildings, the Works can be reinstated and modernized. A case such as this was the Works at Ruthin, North Wales.

Ruthin.

This Works has an annual output of 10 million cu.ft., and is built on a site of approximately half an acre in area. The yard is divided into two sections on different levels, separated by a stone wall. The upper yard contains the purifiers, station meter and the larger of two gasholders, while the lower section contains the retort house and the remainder of the plant and building.

Most of the manufacturing plant was of ample capacity, but had been allowed to fall into a very bad state of repair. The buildings had been equally neglected, and some were too dilapidated for further use. It was decided that a general attempt would have to be made to bring the Works up to standard. The Undertaking was put under the charge of the Manager of the Holywell and Flint Station of the British Gas Light Company, and assistance could be obtained when required from this Station. A member of the Engineering Staff was transferred to Ruthin to supervise the reconstruction of the Works and district.

The retort house was a building of comparatively recent construction, but no attention appeared to have been given to it since its erection, and it was necessary to repoint the whole of the exterior. The chimney also required considerable repairs.

The house contained two beds of six stop-ended retorts of the shallow regenerator type, and both were in such a bad state that some of the retorts could not be charged. An order had already been given, before the Company was taken over, for one bed to be reset, and as soon as this was completed it was necessary to reset the other, including the flues.

Beyond the beds there was space for another arch, which had been partitioned off, and contained a small vertical boiler and acted also as a messroom, and was generally full of dirt and rubbish. The partition was taken down and the space completely cleared. The

boiler was removed to a new site alongside the exhauster house. The retort house floor was relaid with hard fire-brick.

The exhauster house was an exceptionally dilapidated building; there was hardly a window with a whole pane of glass. An exhauster of 2,000 cu.ft. capacity was driven by belting from a countershaft by either of two gas engines, one of which badly needed overhauling. A 3,000 cu.ft. exhauster, direct coupled to a very large and old pattern steam engine, was supposed to act as stand-by, the steam being supplied from the boiler in the retort house with more than 100 ft. of unlagged pipe. This plant was in thoroughly dirty condition. Both exhausters and the older gas engine were overhauled. The steam engine was taken out and a small up-to-date steam engine, purchased second-hand, was substituted. The exhauster house was redecorated and fitted with an additional window.

For the washing plant, there was only a tower scrubber; the by-pass valve of this apparatus had been opened when the grids were renewed a year previously and had never been shut again, but no one had noticed it. A Livesey washer for disposal at Flint Works was brought across and installed.

The purifying plant in the upper yard consisted of two boxes (one dry lute and one water lute) standing in the open, and a third box some distance away in one section of a large stone building, formerly used as a stable.

Although there was also an oxide shed to which the oxide should have been confined, oxide covered the whole of this yard and raised its level from a foot to three feet. The valves of the purifiers were entirely buried so that they were useless and it was necessary to shut down gas-making in order to change a box (the third box was used exclusively as a catch box). This oxide was completely cleared away, new valves fitted to the purifiers, and brick pits built round them.

The station meter was situated in another section of the stables, and was of inadequate capacity and unknown make; it had also a water-sealed by-pass which continually blew. A reconditioned station meter with high-speed drum was purchased and installed on another site.

The larger gasholder, a three-lift of 40,000 cu.ft. capacity, was close to the purifiers, and the oxide had blown on it for many years, with the result that there were a great many leaks in the plates, particularly at the water-line. To put the holder in order, it was necessary to fit complete bands on both lifts and to do other patching, which included almost entirely relining the cups. This work was completed, and the valves were likewise cleared and put in order.

A 6 in. Bryan Donkin diaphragm type district governor did duty for a station governor, and operated at some depth below the floor, and was permanently water-logged. It was originally intended to substitute a bell type governor, but after certain mainlaying work on the district had been completed, it was found to be working quite satisfactorily. It has therefore been retained, but the connections have been altered so as to bring the governor above the floor level.

These were the main repairs required to the plant, but all apparatus, including holders, had to be scraped and repainted. The brick tank of the small 16,000 cu.ft. holder was level with the yard, and a brick wall had to be built round it.

Considerable reconstruction, however, was required to the buildings. In one corner of the Works there were some very untidy and derelict lean-to erections which served as fitting shop, general stores, and governor house. Some old wooden sheds stood in the yard, and part of these were let to the Post Office for storing various articles. There was a small showroom, but no office.

The lean-to building and wooden sheds were dismantled, and also an old weighbridge house, serving as a lavatory. An entirely new range of buildings, comprising governor house, messroom, fitting shop and stores were erected. An office was built as an extension to the showroom, and this necessitated moving the main entrance about 10 yards. The Works weighbridge was on a spare piece of ground on the far side of the Works, entirely out of sight, and this was transferred to the new entrance. A small brick lean-to building, with asbestos sheet roof, was erected to house the vertical boiler alongside the exhauster house.

The old stables in the upper yard, which contained the purifier and station meter, as well as a great deal of rubbish, were in a dangerous state since two walls had badly cracked, due apparently to some settlement. This building was demolished and a new meter house erected. Walls were built in the oxide shed to prevent the oxide being blown on to the holder.

Finally, the drains in the lower yard had to be relaid and the yard levelled.

The reconstruction, which was on a somewhat larger scale than usual, took about one year to complete with district alterations being undertaken simultaneously; a rough division of costs is given below.

	£
Resetting	177
Holder repairs	333
Repairs to plant (including painting)	246
New buildings	601
Repairs to old buildings, yard, including drainage, removal of weighbridge	327

Storrington.

When Works plant is being rearranged, the expense of erecting brick buildings can on occasions be avoided by utilizing wooden buildings of the type supplied by David Rowell and Co., Ltd., Boulton and Paul, Ltd., and others, provided they are to be situated in an inconspicuous place. This was done in the following manner at Storrington, Sussex, where the Works, of 5 million cu.ft. capacity, is on a narrow and cramped piece of ground.

Alterations were required in connection with the carbonizing plant, purifiers, station meter and outlet mains. The purifiers were situated in a brick and tile building with a very rough corrugated iron extension forming a covering over the oxide "floor." The station meter was housed in an old shed in the Manager's garden adjoining the purifier house. The purifiers, consisting of two 6-ft. square boxes, were only just adequate and required frequent changing in the winter. It happened that an 8-ft. square dry lute box was available at another Works, and it was arranged that this should be brought to Storrington and placed in line with the other boxes, with a complete new set of connections, so that any of the three boxes could be worked as first box. The installation of the new purifier meant pulling down the end wall of the house and moving the meter shed. This presented an opportunity to have a general rearrangement of this part of the Works with a new meter house and oxide shed.

A quotation was obtained from David Rowell and Co., Ltd., for a wooden building with asbestos sheet roof to comprise an oxide shed, meter house and small store. With this arrangement, the oxide shed formed a continuation of the purifier house and the meter came at the side, which involved some rearrangement of connections. The result was a vast improvement in the appearance of that part of the Works, and incidentally screened off the purifiers from the Manager's house.

The dimensions of the building were 15 ft. 6 in. by 24 ft. by 7 ft. to the eaves; the cost was £90, including junction with existing roof and guttering.

Other work at Storrington included relaying the 6-in. outlet main, which descended to a depth of 6 ft. in order to pass under a stream just outside the gates, and installing a station governor. The new outlet was laid with steel tube at a normal depth and carried over the stream in the road arch. The governor, imported from another Station, was housed in an extension to a new showroom and office adjoining the Works entrance, and connections were taken from the new outlet main.

Coke Cutter.

A coke cutter is an undoubted advantage at small Undertakings, because if there is not already a demand for small coke for domestic boilers and other purposes a market can often be created. In the past, no cutter had been made which was suitable for the smallest Works. We have urged manufacturers to produce a

machine of a capacity of about 1 ton per hour at a proportionately small cost. Such a plant is now marketed by Aldridge and Ranken, Ltd., and the first was installed at Storrington. It consists of a small " Nelson " cutter of 1-2 tons per hour capacity with a shaker screen giving coke of two sizes, 1 in. or 2 in. The overall length is only 8 ft. 6 in., and it is driven by a 7½-H.P. Stockport gas engine (from one of the other Works). Only a small percentage of breeze is made.

It may often happen when a plant is displaced by the erection of new plant on another site that existing buildings become available and can be used for entirely different purposes from those for which they were originally intended.

In reorganizing the Works at Trowbridge, Wilts., to increase the manufacturing capacity sufficiently to supply the adjoining town of Bradford-on-Avon, a purifier house is being converted into a boiler and engine house. At Holywell, North Wales, where reorganization is taking place for similar reasons, the old sulphate house is also being divided to form a boiler and engine house.

Westgate.

At Westgate, when the new carbonizing plant was erected, good use was made of the old retort house—a building 70 ft. by 43 ft. inside. The coal elevator, fed from the adjoining coal store, and the coal hopper were retained therein and light track with Decauville trucks was run from beneath the hopper to the new carbonizing plant. This occupied about a quarter of the ground space within the house.

Further space was utilized for some reconditioned exhausting sets purchased to replace the old sets, which were both very old and inadequate and which were situated in a small building. Two rotary compressors supplying the district high-pressure system were housed in another small building near the Works entrance some considerable distance from the rest of the manufacturing plant, and it was arranged that these also should be installed with the larger exhausters in a new engine room in part of the old retort house.

Even allowing for a good-sized engine room, only half the available space in the old house was occupied. A steam wagon had been purchased to transport coal from the colliery 8½ miles away, and this required a garage. The men's messroom was too small and no bathroom was available. A new stores was needed. It was found that all these three requirements could comfortably be fulfilled in the remaining half.

Plans were drawn up and the work put in hand, which incidentally provided temporary employment for men whose services were no longer required when the new carbonizing plant went to work. The front entrance to the retort house was incorporated in the engine room and a framework with glazed panels and a doorway was built in. New and large windows were let into the side and end walls of the building forming the exterior walls, and the new sections were built with flat roofs.

Instead of the usual narrow subway found in this type of retort house, the floor had been built in a series of arches, so that beneath there was a large vault. This proved very useful in the case of the engine room as all the connections to the engines and boosters were taken under the floor where they could easily be seen and inspected. The heavier pipes were supported with brick piers and steel stanchions. Drainage was taken to a large cast iron tank in this basement. The floor was reinforced with steel joists, but in the case of the garage, messroom and stores, which are on the site of the old bench, the brickwork below the floor level was left in to give additional support.

After these alterations were completed, there was still room available for the water tube condenser which when the new exhausters were installed had been left on the pressure side. This apparatus has now been transferred to the vacuum side within the building and is conveniently situated away from extremes of atmospheric temperature, which were experienced on the old site. This condenser, which weighs some 20 tons when working, stands at floor level and is carried by concrete reinforced by steel joists supported by stanchions from the subway.

The complete cost of this work, including the transfer of apparatus, was £1,173.

DISTRIBUTION.

(*a*) Low Pressure.

The distribution side of a small Undertaking may often require more reconstruction than the works side, owing to the unfortunate habit in the past of laying trunk mains of 3 in., 2 in., and even 1½ in. diameter. It must be remembered, however, that the mains were put down very many years ago, and those responsible were probably hindered by lack of capital and did not anticipate to what extent consumptions would grow.

The work of putting a district in order may often be hampered by no plans being available. If there is the good fortune to find plans, the work is simplified because it can be seen at a glance where there are mains of inadequate size serving large areas, and it is only to be expected that low pressures will be found in confirmation; where plans are not available, pressures must be taken in all parts of the district—preferably with recorders—and excavation made to find the size of pipes.

It may be that new feeder mains are required to form a circuit or in other ways augment the supply, or that an extensive programme of relaying existing mains will be necessary to provide an adequate supply. When much work is required on the district of an Undertaking, it has been found to be an advantage to draw up a schedule of all that is needed to put the district in order, and then to obtain tenders from firms of mainlaying contractors for the whole work.

It is not possible to include relaying services in the contracts, as it is difficult to find out at once which ones require replacing.

It is useful when an Undertaking has been taken over to send a representative of the Company (perhaps a fitter from one of the larger Stations) to visit all the houses to take details of their apparatus and any complaints; this forms a good guide for ascertaining which services require attention and for confirmation concerning bad areas.

Ruthin.

At Ruthin, North Wales (10 million cu.ft. per annum, 2,900 inhabitants), both relaying and a feeder main were required. The centre of the town is to the south of the Gas Works at the top of a fairly steep hill with the Gas Works at the foot. Very many of the mains were too small (3 in. and less), and continued down the hill again on the south and west sides, where the district extended for some way on flat ground. Here, as might be expected, the pressures were very low (below 2 in.), and at the far end of one long street there was no gas at all, so that the consumers had given up trying to use their apparatus.

The holder threw 11 in. of pressure, and it was the custom to put the whole of this pressure on the district in an endeavour to get the gas to the bad area. To overcome the trouble, a 6 in. steel main was laid from along a road round the foot of the hill to join with the bad area. In addition to this, some 700 yards of 4 in. main were laid in streets containing the small sized mains. Instead of cutting off these small mains, except in the case of 1½ in., the new mains were used as feeders, thus saving the expense of transferring a large number of services.

When this work was finished, the pressure at the Works was reduced to 5 in., and at no point on the district was there less than 3 in. The cost of laying 2,300 yards of 6 in. and 4 in. was £1,700.

Occasionally a distribution system will be adequate at the time of taking over, but after the sales have been pushed and many new houses have been added, a general collapse will come suddenly as though the addition of the last few houses was, as it were, the " last straw." This was the case at Bradford-on-Avon, Wilts., and Fenny Stratford, Bucks. At both these places, complaints of poor supply began within a short period from all districts. At Bradford-on-Avon the village of Winsley, some two miles away, is supplied by low pressure, the main being

a branch from one of the trunk mains, and naturally this place suffered most. It was necessary to replace 930 yards of 4 in. and 3 in. pipe with 7 in. and 6 in. pipe, besides some smaller relays.

At Fenny Stratford some 680 yards of 5 in. and 2 in. pipe had to be relaid with 10 in. and 8 in.

(*b*) Boosting.

For supply to a distant village or to a holder station, boosting has been adopted whenever possible, owing to its elasticity and the advantage of being able to use a smaller size main.

When a distant village is supplied by low pressure and the consumption has grown beyond the capacity of the main, there is often difficulty in reinforcing the supply by the use of a compressor because there are many services from the main which would have to be fitted with governors if the pressure is to be raised more than a few inches, and this would make the remedy an expensive matter; also because the main may not be a separate one commencing from the Works but a branch from another main, and extra pressure is lost through connections to other parts of the district, before reaching it.

Trowbridge.

At Trowbridge, Wilts., the village of Holt, three miles away, is supplied by a low pressure main branching from about 500 yards of 4 in. main, with many bends. A fan booster was installed to raise the pressure in Holt, but although the extra 6 in. which the booster gave should theoretically have increased the terminal pressure by at least 2 in., it only made about $\frac{1}{2}$ in. difference. There were several connections from the 4 in. main to other parts of the district which it was suspected might give trouble, and non-return valves were fitted to each. Very little improvement however was effected, and it has been necessary to lay a new feeder main, by-passing the earlier part of the original main.

Where there is an area of low pressure within a town, compressing as a remedy has been successfully applied by running a feeder main to supply into the low pressure mains through a governor. When the district is of a long or scattered nature, a series of high pressure feeder mains to the more distant points (a system very popular in America) is a useful means of keeping the pressure adequate and constant, and may save extensive main-laying.

High Pressure Feeders.

At Westgate and Birchington, Kent, where the Gas Works is situated between the two towns and the district is scattered, this method has been satisfactorily applied, and an extensive system of high pressure feeders, running to the extremities of the district, feed into the low pressure main. The high pressure outlet main from the Works is an 8 in., and this divides into 6 in. branches, one going to Westgate, the other to Birchington. At these places they split up again into a number of 4 in. feeders, the farthest point being $2\frac{3}{4}$ miles from the Works. The governors used are Reynolds type (size 3 in.). The system is shewn in Figure 2.

At this place the method was originally adopted as an alternative to relaying a large portion of the district mains, many of which are only 3 in. in diameter, and it is found that the pressure is kept uniform. At the Works there are two steam driven rotary compressors, one of 40,000 cu.ft. capacity, and one of 20,000 cu.ft., the larger of which can compress to 5 lbs. per square inch. To maintain a pressure of 4 in. at the extremities of the district required 4 lbs. initial pressure with a maximum hour of 50,000 cu.ft. (before the extensions described in the next sub-section).

The system is the same as that applied at Gorleston and Southtown, Norfolk, where the district is somewhat in the shape of a dumbbell, as it runs along the river front, the Gas Works lying between the two main sections. There, reciprocating type compressors are employed delivering into a receiver. The pressure at the outlet of the receiver is 12 lbs., and this is broken down to 5 lbs. for a feeder main running to Gorleston, where it supplies into the low pressure main at several points. On the Southtown side the pressure is broken down to 7 in. within a short distance and fed into the district mains.

There are three holders at Gorleston, none of which give a greater pressure than 4 in., and the boosters are therefore run from 7 a.m. to 11.30 p.m. When the boosters come into action, a counter-balanced flap valve on each of the trunk mains closes against the gasholders. Should there be any breakdown of the compressing plant, the holders would automatically come into operation.

When a supply is given from a Works to a holder station, it has been found expedient to use compressors so that the holders can be filled in a space of two or three hours, and also for the elasticity previously mentioned.

It is difficult to give costs of boosting on Small Works where labour, steam and lubricants are not apportioned and where conditions vary greatly, but some approximate figures are given in Table IV.

Table IV. - *Approximate Costs of Boosting on Small Works.*

Size of Works.	Gas Compressed per Annum.	Pressure.	Boosting Hours per Diem.	Cost per 1,000 Cu.Ft. Compressed (including Repairs).
1	2	3	4	5
Million Cu.Ft.	Cu.Ft.	Lbs.	Hours.	d.
26	15,700,000	5	24	$1\frac{1}{4}$
26	,,	5	12	1
74	55,000,000	12	15	$1\frac{3}{4}$-2
95	22,000,000	4½	15	$1\frac{1}{4}$

(*c*) Direct High Pressure Supply.

When gas is taken to a new district an opportunity is occasionally presented for giving what is undoubtedly the most satisfactory form of supply, namely, high (or medium) pressure to the door of the consumer. Such an opportunity occurred at Westgate, a description of which follows.

The village of St. Nicholas-at-Wade, Kent, is $2\frac{3}{4}$ miles to the west of Birchington, and up to 1930 the inhabitants had to rely on oil for lighting and solid fuel or oil for heating. The village is in the area of supply of the Westgate and Birchington Gas Company, and the inhabitants petitioned the Company for a supply of gas. Accordingly, a canvass of the village was made and the cost of providing for the supply estimated. Since, as already mentioned, there is a high pressure system reinforcing the low pressure mains in Birchington, it would be a comparatively easy matter, by an extension of the high pressure line, to take gas to St. Nicholas.

The result of the canvass indicated a consumption of 1,800,000 cu.ft. per annum, and as the extension appeared hardly to be a paying one, the matter was postponed for a time. A further request came however for the decision to be reconsidered, and in view of the rumours that the Electricity Company had its eye on St. Nicholas, and the fact that an efficient gas supply would be good propaganda for the Company, it was decided to accede to the request, although the yield promised only to be in the neighbourhood of 5 per cent. It was arranged to have direct high pressure supply. With an initial pressure at Westgate Works of $2\frac{1}{2}$ lbs. per square inch, the pressure in the " Square " at Birchington, from which point the new main would run, was 30 in. at peak load, and as the Works pressure could be increased by at least another $2\frac{1}{2}$ lbs. it was seen that the probable maximum hour of 6,500 cu.ft. could easily be dealt with by a 4 in. main. About the same time, however, another village—Acol—which is just over a mile from Birchington on a road branching from the St. Nicholas Road, also asked for a supply, and their estimated consumption proved to be 750,000 cu.ft. per annum. With the possibility of this additional load in mind, the diameter of the first 1,000 yards of main was increased to 5 in., and the whole main was laid with solid drawn steel tube with inserted joints for welding.

In the village of St. Nicholas, the mains are all 3 in. diameter, and $\frac{3}{4}$ in. " Pro-gas " governors are fitted at the inlet of each consumer's meter and are set to give $3\frac{1}{2}$ in. pressure. For the Chapel, Village Hall, and other public buildings, the governors are 1 in. and also set for

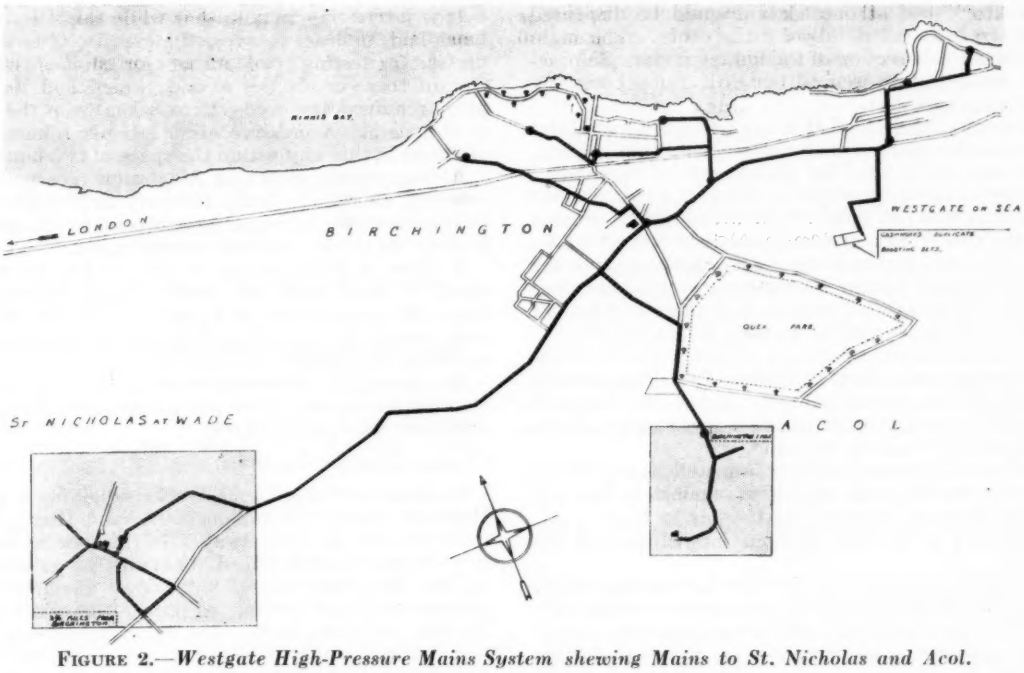


FIGURE 2.—*Westgate High-Pressure Mains System shewing Mains to St. Nicholas and Acol.*

3½ in. pressure. These governors are claimed to give a steady outlet pressure over a wide variation of inlet pressure. The maximum permissible inlet pressure for the governors at St. Nicholas is 28 in., and although in the normal run it was unlikely that more than this pressure would reach them, it was decided as a precaution to install a Bryan Donkin " Reynolds " type governor at the entrance to the village, this being set to give an outlet pressure of 15 in.

Shortly after this work had been completed, the Directors decided to take the supply to Acol, although this also seemed hardly a remunerative proposition, and a 3 in. steel main was laid which branched off from the St. Nicholas main, 500 yards from its commencement. In this village Pro-gas governors were again used and a Reynolds governor was again fitted at the end of the trunk main, as at St. Nicholas.

The supply has been completely successful and has greatly pleased the inhabitants. The consumption at St. Nicholas has exceeded the estimate and is in the neighbourhood of 1,956,000 cu.ft. Nearly all the houses are fitted with lights and cookers, and the public buildings, including Church and Chapel, have also been well lit. The boosters are run for 18 hours every day, and it has not been found necessary to increase the inlet pressure to more than 4½ lbs. The Manager has fitted a Klaxon hooter alarm outside the booster house which operates by a mercury contact if the booster stops and the pressure drops.

At night-time sufficient gas passes to the villages at low pressure and the service governors open out so that consumers still get 3½ in. pressure.

At the conclusion of the St. Nicholas work, the Manager gave a supper in the Village Hall to the men who had taken part, and although two large cookers and some rings were temporarily in operation in addition to the full lighting and radiators, there was no drop in pressure. This would appear to support the makers' claim for a " rising tendency " in the outlet pressure of the Pro-gas governors.

The cost of the extension to St. Nicholas was as follows:—

	£
Laying 1,000 yds. of 5 in., 4,850 yds. of 4 in., 1,550 yds. of 3 in. (in the village)	2,659
Laying services and fixing governors	322
Carcassing and fitting up houses (including fixing stoves and meter, but not purchase)	210

LINKING-UP.

When control is taken of a Works which is situated only a few miles from an existing Works, serious consideration is given as to whether manufacture can be concentrated at one or other of the Stations with the consequent saving in manufacturing costs.

There are many factors influencing a decision in each case, which preclude any attempt at laying down rules, and these are such points as (1) size of the Undertakings, (2) distance apart, (3) topographical nature of route between works, (4) whether the main linking the works would pass through an area where additional consumption could be obtained, (5) the expenditure that would be involved in increasing the capacity of the manufacturing plant at either works to enable it to deal with the whole load, (6) the question of transport of coke for sale at the works which is to be shut down, and the price of its disposal there.

Holywell and Flint.

Where there are two Works of approximately the same size, it is probable that there will be considerable expense on the manufacturing plant, unless one of them is unusually well provided. There may also be difficulties in the way of maintaining the supply while the alterations are in progress. At Holywell and Flint, North Wales, this difficulty was met by linking both places before making the alterations to the manufacturing plant. The two Works, which have each an output of approximately 25 million cu.ft., are four miles apart, and the mining village of Bagillt lies midway between and was supplied from Holywell. Both were equipped with similar plant, and it was obvious that considerable economies could be made by closing down one Station; but it was some time before a decision could be reached as to which would be the more suitable Works for manufacture, as both had advantages. Flint was the more central position and had a large flat piece of land adjoining the Works, which was excellent for extensions, but had no possibility of a railway siding. At Holywell, on the other hand, rather less expenditure on plant was necessary and a siding was a possibility; also the Works were in a much less conspicuous position than at Flint. The water supply however was not so good.

Both Works were very short of storage accommodation, and at both it was necessary during the winter to have an additional bed of retorts under fire to take up the extra load, but in neither case was it doing full work. Pending a decision with regard to the manufacturing centre, it was arranged to lay a 6 in. steel main from Flint Works to Bagillt, to connect into the mains in the village, and fit valves at two points so that a considerable portion of this load could be borne by either Works, according to the stock available. It was hoped also that by this means

the "floating" bed at one Station could be dispensed with and the load taken fully by the other. The main would form the first section of the linking main. In practice, this worked quite well, although it did not entirely eliminate the spare bed.

It was eventually decided that the advantages of Holywell as a manufacturing station outweighed those of Flint, and work was put in hand for the alterations required.

The storage capacity required increasing by 200,000 cu.ft. which it was felt should with advantage be divided between the two Works, and two holders of 100,000 cu.ft. capacity each were put in hand. An order was given for a bench of Jenkins' Klönne intermittent vertical chamber ovens of 1·5 tons capacity (one bed of three and two of two each) to be erected in the existing retort house.

New (reconditioned) exhausting plant has had to be installed, together with a new Cornish boiler. The washing plant has had to be transferred on to a new site and part of it replaced by plant from Flint; a great many of the works mains have had to be relaid.

Two rotary compressors have been installed, capable of dealing with 20,000 cu.ft. per hour against 5 lbs. per square inch pressure for pumping the gas to Flint.

All work had to be done without interruption of the supply.

In order to make room for the new carbonizing plant, part of the retort bench had to be demolished so that only two beds were left standing, and it was necessary before this work was commenced to complete the 6 in. linking main and to insert a third valve in Bagillt so that still more of the village load could be taken by Flint.

It happened that there was an extra heavy load in the whole district during the winter, and much activity was caused to the staff by the changing of valves according to the stocks in the existing small holders. The arrangement however worked satisfactorily.

At Bagillt the high-pressure main has been connected to the low-pressure mains through governors, so that with the new compressors in operation a small fan booster, which had previously been used at Holywell during the peak load hours, could be dispensed with. It is only intended to boost for a few hours each day to fill up the holders, and for the remainder of the time there will be sufficient difference of pressure between the old holder at Holywell and the other two at Flint for gas to pass on its own. Another point of interest in this linking was that the declared calorific value at Flint was 510 B.Th.U.; and permission had to be obtained to reduce it to Holywell's calorific value of 500 B.Th.U.

It is not possible to give definite figures for the cost of all these alterations, as the work is not quite complete, but there is every reason to suppose that the savings will be considerable.

Aldeburgh and Leiston.

Sometimes it does happen that no extensions are required to the manufacturing plant. This was the case at Leiston, Suffolk, when it was decided to give a bulk supply to Aldeburgh, four miles away. The two Works had both an output of approximately 13 million cu.ft., and at Leiston where the carbonizing plant consisted of three beds of stop-ended horizontals, only two were in use. The remainder of the plant was of ample capacity to deal with the extra load, and although there had been certain claims for Aldeburgh to be the manufacturing centre, for this reason Leiston had been chosen. The only expense on the Works was the purchase of a vertical boiler to act as standby.

Between Aldeburgh and Leiston, but about two miles to the east, is the new coastal resort of Thorpness, and this place was supplied by a 4 in. high-pressure main from Leiston, the pressure being reduced to low pressure through a governor before the gas entered the town mains. Compressors were therefore already in existence, and as these were of 15,000 cu.ft. per hour capacity against 5 lbs. per sq. inch, they were sufficient to deal with the Aldeburgh load.

The high-pressure main ran for a mile along the Aldeburgh road, and it was therefore only necessary to extend it by three miles to bring gas to Aldeburgh.

It is interesting to note that while this 4 in. main was being laid, in order to avoid the expense of hiring a compressor for testing, two motor-car engines were used. One of these drove the second, which had its sparking plugs removed and connections taken from the cylinders to the main. A pressure of 50 lbs. per square inch was obtained in this way within the space of two hours.

A Connersville meter at Aldeburgh measures the gas received, and it was found necessary to fit a governor just before the meter to reduce the pressure to a constant 7 in. in order to ensure accurate measurement.

A valve is fitted on one of the holders at Aldeburgh which is closed when the holder is full, thereby slowing down the compressors at Leiston. At this Station the compressors are run throughout the 24 hours in order to maintain the supply to Thorpness.

By linking up Aldeburgh with Leiston, the saving has been approximately £360 per annum and the capital expenditure was about £2,000.

Halstead and Hedinghams.

Another case of a larger Works supplying a smaller is Halstead, Essex, 34 million cu.ft., and Hedinghams, 1½ million cu.ft., 4½ miles away. In this case no alterations were required at Halstead, but with an expenditure of £4,240 for compressors, 3 in. steel main, meter and governors, it was possible to reduce the cost into holder by 10d. per 1,000 cu.ft.; the consumption has since, in five years, grown to 4 million cu.ft. per annum. At Hedinghams, there is a branch connection with governors, so that gas can be supplied direct into the district mains, the excess going into the holder.

Trowbridge and Bradford-on-Avon.

An instance of a larger works requiring extensive alteration to give a bulk supply to a smaller is Trowbridge, Wilts. (117 millions). The Bradford-on-Avon Gas Company (31 million cu.ft.) is only 2½ miles away, and as considerable repairs were required to the plant it has been decided to close the works.

Rotary compressors, capable of dealing with 20,000 cu.ft. per hour with an initial pressure of 2 lbs. per sq. in, are being installed.

The main is being laid by as short a route as possible, and this has involved two wayleaves—an expense which is apt to be forgotten in estimating—and branches will be taken from the high-pressure main into the low-pressure mains in Trowbridge and Bradford so that the pressures can be backed up at times of peak load.

In order to give this supply, very heavy expenditure and a great deal of work has been necessary at the Trowbridge Station, as the plant generally is cramped. On this account the matter had at first been postponed, but when the needs of Bradford became more urgent, it was decided that in the long run the expenditure would be justified by the economies anticipated, particularly as some extensions would have been necessary at Trowbridge in any case.

The work is proceeding at the present time. The retort bench of five settings of 16-ft. through horizontal retorts is being extended by a further three settings. There was room in the retort house for this extension, but unfortunately as a war-time measure two Lancashire boilers had been installed right across the stoking machine track, and these had first to be moved. The overhead purifiers were barely adequate for present needs and they have been replaced by a new set of boxes at ground level. Half of the old purifier house is being converted to a boiler house for the Lancashire boilers and the other half will serve as an engine house, in which exhausters, generators and boosters are being concentrated. The washing plant is being increased together with a general rearrangement of connections.

All this work is complicated by the fact that the manufacturing plant must be kept going to maintain the supply in Trowbridge.

The main to Bradford is to be 6 in. steel, and is being laid before the alterations are completed, as in the case of Holywell and Flint, so that sufficient gas can be sent to Bradford to avoid the necessity of lighting up another bed of retorts during the time of heavy load.

Town Gas in the Steel Industry

By Dr. H. ALEX FELLS, B.Sc., A.I.C., A.M.I.Min.E.,

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Broadly speaking, there are two features in the heating of steels, referred to in the trade as " Re-heating " and " Heat-treatment." " Re-heating " is a general term applied to any process of heating for the rendering of the steel into a suitable physical condition to receive mechanical work. The rolling of ingots and billets into bars of smaller sections, wire, or sheet, the forging or drop stamping of steel, by hand or by power-driven units, into mechanical units or tools such as cutlery, files, small tools, and crank-shafts are examples of processes where the main function of heat is to render the steel capable of being changed in form by mechanical pressure. " Heat-treatment " is carried out for the specific purpose of changing the internal structure of a steel and consequently of giving a steel desired physical properties. It will be appreciated that it is largely the heat-treatment of a steel which ultimately determines its value when fabricated as a mechanical unit or tool.

The heat-treatment of steels is a factor very closely governed by precise metallurgical requirements, and many different heat-treatment operations are carried out according to the type of steel being used, and the use to which it is to be applied. The annealing of steel is carried out to obtain maximum softness, and involves slow cooling to give re-crystallization of the metal. Normalizing removes strains caused by mechanical work, and more rapid cooling is used than in annealing to preserve the refined grain structure, resulting in a tough material.

Heat treatment for hardening results in re-arrangement of the constituents of a steel, the formation of new compounds and aggregates and particular physical distribution of these throughout the body of the steel. Such changes are directly dependent upon the temperature used, and upon the time of heating, and different types of steel require their own particular conditions of temperature and time. Since the advent of high speed steels and stainless steels, these conditions have become very much more exacting than those appertaining to the older simple steels.

These brief references to a few of the functions of heat in the steel industry are made to indicate the important part taken by fuels in the technical development of steels.

MODERN REQUIREMENTS OF A FUEL.

The increasingly exact requirements of industry to-day make demands on the economic and optimum use of fuel not previously deemed essential, and where the privilege of choice can be used, a fuel in the gaseous form is preferred. There are many features of a fuel which are looked for as being desirable for economic use, and it is not a simple matter to obtain all these features in any single fuel. Of these features the following may be given as the principal ones generally acknowledged in the steel trade; the major features of a desirable fuel are those dependent and consequent upon its methods of combustion:—

(1) It should be capable of being easily and completely burned by simple and inexpensive methods.

(2) It should be capable of control to give any desired temperature over a wide range.

(3) The temperature for any one process should be capable of being attained quickly, and maintained uniformly constant for any desired period.

(4) The systems of combustion used should be such as will allow maximum recuperation or regeneration of heat by salvage from waste products of combustion.

(5) The type of flame obtainable should be such as will allow suitable distribution of heat throughout a furnace working chamber.

(6) The maximum amount of heat to do useful work should be attainable from the total heat in the fuel, *i.e.*, a fuel should give as high a thermal efficiency in a furnace as possible.

The secondary features of a fuel acknowledged to be desirable, and which have a definite bearing on its economic application, may be summarized as follows:—

(*a*) It should be readily available at all times and not be subject to vagaries of supply.

(*b*) It should be of uniform quality and constant calorific value.

(*c*) Oncosts for handling, storage, removal of waste products, attention during use, should be as small as practically possible.

(*d*) It should be capable of being used in any type of furnace, and should allow of its use in special designs of furnace for particular processes.

(*e*) The fuel should not give rise to atmospheric pollution by black smoke.

Finally the all important items of initial cost influence the user of a fuel to an extent usually greater than those items already mentioned. It is steadily but positively being appreciated by enlightened industrial users of fuel in the steel industry, that those features required of a fuel, other than initial cost, are an economic advantage, and have decided practical influence on the ultimate overall value of a fuel. Where a gaseous fuel, such as town gas, is available for large scale consumption at initial costs which on a thermal basis alone are competitive with other industrial fuels, this fact, coupled with the other acknowledged valuable feature of town gas, is creating a demand for such a fuel not previously realized.

TOWN GAS AS A SOURCE OF INDUSTRIAL HEAT.

Modern industrial requirements in the steel industry are such that the amount of wasted steel due to incorrect heating must be kept at as low a percentage as possible, and it is only by being able to guarantee the same physical and *chemical* conditions in a furnace working chamber *at all times* that success in this direction can be hoped for.

What these physical and chemical conditions are is a matter of major importance, and a consideration of them coupled with close attention to furnace design and methods of combustion has taken a prominent part in the adoption of town gas in the steel industry both in this country and abroad.

Features of Town Gas as a Modern Fuel.

Before giving a detailed account of practical applications of town gas to steel processes, a reiteration of some of its features will indicate how it meets the requirements demanded of a modern fuel.

1. It is a fuel which can be easily and completely burned in many ways, in burners of simple and robust design.
2. The type of flame produced can be readily adjusted to secure the type of heat distribution required.
3. The degree of combustion can be varied in such a way that the exact amount of air required for complete combustion can be precisely determined and used, or any desired excess of air or of gas, within certain limits, can be obtained.

4. The high air/gas ratio required for combustion enables greater use to be made of waste heat recovery by recuperation or regeneration.
5. The control of temperature, type of flame, and possibilities of heat recuperation allow of unique furnace design to meet special practical conditions of processing, not easily attainable with other fuels.
6. Many of its secondary features, such as freedom from vagaries of supply, constant calorific value and uniform quality, minimum oncosts, since storage, handling, removal of waste products are practically eliminated, and ease of transport in the works, make a very practical appeal.

Conditions Required in a Furnace.

Having briefly reiterated the claims for town gas as against other forms of fuel for industrial heating of steels, it will be an advantage to see how we are justified in making some of the claims. Earlier in this Paper mention was made of the desirability of maintaining the same physical and chemical conditions in a furnace if consistent results are to be expected. These physical and chemical conditions naturally differ for different heating operations, but in general they may be defined as follows:—

(*a*) A definitely known temperature, only varying between certain limits.
(*b*) A uniform, or uniformly graded, temperature throughout the working chamber.
(*c*) An easily obtained temperature, obtainable usually in a minimum of time.
(*d*) A temperature which can be maintained uniformly for any desired period.
(*e*) A positive pressure inside the working chamber in order to exclude free air, *i.e.*, to prevent the entry of free air through the furnace door or through any opening in the furnace structure.
(*f*) A suitable mixture of gases, referred to as "an atmosphere" in the working chamber to produce this positive pressure, such as will have the minimum chemical effect on the surface of the metal being heated, or as will have any particular effect as may be desired.

Speaking in a general way, the foregoing desirable conditions are those usually demanded of a furnace used in the steel trade, and when conditions with respect to the type of atmosphere in the working chamber are not so exacting, the conditions with respect to temperature remain the same.

It is agreed that the six items mentioned as being essential for the satisfactory functioning of a heating chamber are perfectly true in practice, but it is equally agreed that the cost of obtaining that condition is the major consideration in many instances. In considering the matter of cost, attention must be given to the amount of money lost in *not* maintaining these conditions. Where no precaution is taken to obtain optimum conditions of temperature and atmosphere composition, the percentage of metal spoiled and wasted, the labour charges for work requiring to be done a second time, the material lost as scale and surface damaged steel, the expensive grinding and machining to remove damaged metal and pickling in acid baths, are all items which add very considerably to the cost of steel heating processes. In short, in many heating operations, the bulk of the cost of heating does not lie to the cost of the fuel used, but to the many expensive processes necessary to remove or repair the surface and internal damage done during heating. The effects of the chemical conditions in a furnace require to have separate consideration, and will be discussed in the final section of this Paper. The matter of temperature, its constancy, its uniformity and ease of attainment is not only concerned with the mechanical and metallurgical processing of steels, but is naturally very intimately connected with the important factors of furnace efficiency and burner design.

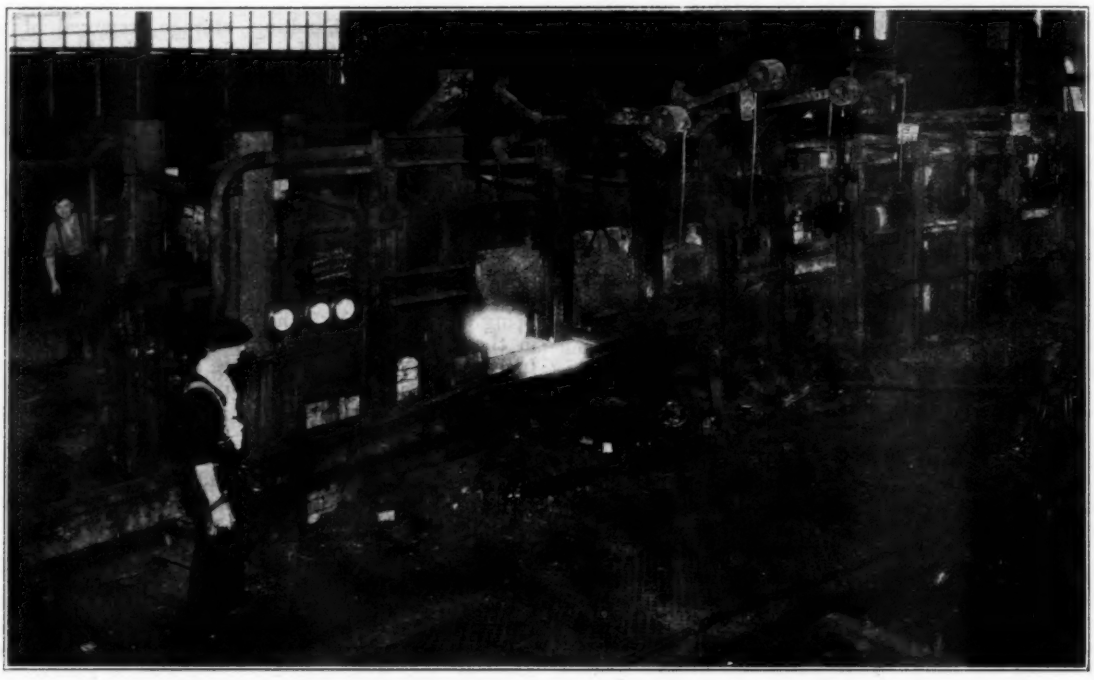


PLATE 1.—*Continuous pusher-type furnace for billet heating originally fired by producer gas and converted to town gas. Two-stage high-pressure gas injector burners are used in three banks, one at the end and two on the sides of the furnace. The capacity of the furnace is 4½ tons per hour and it has an efficiency of over 50 per cent. The billets are heated at 1250° C.-1300° C., and are pierced by a press to form tubes to be later extended to form boiler tubes.*

(*a*) Billet Heating for Rolling.

One of the commoner types of billet heating furnaces in use, employing town gas, is designed to preheat the billets progressively along the furnace. The heating chamber may be anything up to 60 ft. in length, with the burner equipment at the discharge end, the products of combustion passing along the whole length of the chamber. The billets are fed into the furnace by a " pusher " mechanism, or live roller gear, electrically, mechanically or hydraulically operated, at a constant rate. This rate of supply is determined by the size and weight of the billets, the temperature required, and the output required per hour from the rolling mill. But these are not the only determining factors, in the case of certain types of steel. These steels require to be heated at very particular rates, and to remain at certain temperatures for particular periods, for specific metallurgical reasons which determine the physical properties of the steels. In these simple billet-heating furnaces, the burner equipment may be one of several types. Burners giving complete combustion and short flames of maximum temperature, such as high pressure gas, single or two-stage burners and air-gas uni-lever controlled burners are quite common. In such cases no attempt at waste-heat recovery by air-recuperation is attempted, or, in fact, is possible for reasons already given. The pre-heating of the load only is the method employed. Similar furnaces often use what is known as the radiant type burner, using gas and air at low pressures, and not pre-mixing them. The air and gas enter the furnace by concentric tubes, and mix immediately after leaving the burner, giving a long luminous flame. By careful control of the proportions of air and gas, the rate of combustion can be adjusted to approach completion before reaching the cooler end of the chamber. Such a burner system allows the use of pre-heated air by recuperation, and assists the thermal efficiency of the furnace, in addition to the assistance given by preheating of the incoming billets.

The latest type of billet heating furnace, however, not only makes use of the pre-heating of the load, and preheating of the air by recuperation, but at the same time combustion is carried out in a manner specifically designed to give atmosphere control.

In the commoner types of billet heating furnaces previously mentioned, it is quite common to obtain surface damaged steel due to excessive temperatures at the discharge end of the furnace causing burning, and to inflow of air at furnace openings along the length of the heating chamber where sufficient care is not taken to maintain a positive furnace pressure. These difficulties can be largely overcome by use of suitably designed furnaces incorporating the recently marketed " Diffusion Flame System " of combustion.

Table I.—*Record of Gas Consumption of Furnace of Large File Point Rolling Machine.*

Date.	Consumption in Cubic Feet.	Number of Hours Worked.	Number and Description of Files Forged.
1	2	3	4
April 10	1,200	8	6 doz. half round 16 in. 16 ,, flat 14 in.
,, 11	1,100	8	50 ,, flat 14 in.
,, 12	1,200	8	44 ,, flat 14 in.
,, 13	1,200	8	50 ,, flat 14 in.
,, 14	500	4	25 ,, flat 14 in.
,, 16	1,100	6	40 ,, flat 14 in.
,, 17	1,000	8	48 ,, flat 14 in.
,, 18	900	7	48 ,, flat 14 in.
,, 19	1,300	8½	24 ,, flat 14 in. 16 ,, half round 16 in.
,, 20	1,100	8	32 ,, half round 16 in.
,, 21	600	4	16 ,, half round 16 in.
	11,200	79½	

Total weight of files heated . . . . . 93 cwts.
Average consumption of gas per hour . . . . . 141 cu.ft.
Gas consumed per cwt. of files forged . . . . . 120½ ,,

Taking gas as costing 4·8d. per therm or 2s. 0d. per 1,000 cu.ft., then cost of gas per cwt. of files forged 2·91d. and the cost of gas per hour 3·38d.

Sheffield, 19th March, 1934.

Table II.—*Data of Furnaces for Boiler-Tube Manufacture.*

Billet-Heating Furnace.

The data here given is relevant to the furnace shown on Plate 1.

Process	Billet heating for piercing and drawing tubes
Date installed	December, 1933
Operating temperature	1,300° C.
Burner equipment	High-pressure gas 2-stage injectors, Selas type
General dimensions of furnace	50 ft. long by 5 ft. wide by 10 ft. hearth

Results of One Week's Run.

Total gas used in one week	1,603,300 cu.ft.
Throughput of billets	390·1 tons
Throughput of finished tubes	358·3 tons
Gas consumption per ton of billets	4,108 cu.ft.
Gas consumption per ton of finished tubes	4,473 cu.ft.
Thermal efficiency of furnace over one week's run	40·5 per cent.

NOTE.—On a single day's test run for maximum efficiency test purposes, the gas consumption per ton of billets heated was 3,200 cu.ft., giving a thermal efficiency of 52 per cent.

Reducing Mill Furnace.

The data here given is relevant to the furnace shown in Plate 2.

Process	Heating tubes for reduction in diameter
Date installed	January, 1933
Operating temperature	900° C.
Burner equipment	Low-pressure single valve system of British Furnaces Limited (Chesterfield)
General dimensions of furnace	50 ft. long by 3 ft. 6 in. diameter
Total gas used in one day	241,500 cu.ft.
Throughput of tubes	78·5 tons
Gas consumption per ton of tubes	3,076 cu ft.
Thermal efficiency of furnace	37·2 per cent.

Annealing Furnace.

Process	Continuous annealing
Date installed	1929
Operating temperature	800°–850° C.
Burner equipment	Low-pressure single valve system of British Furnaces Limited (Chesterfield)
General dimensions of furnace	35 ft. long by 4 ft. 9 in. diameter
Gas consumption per hour	6,000 cu.ft.
Throughput of tubes per hour	2 tons
Thermal efficiency of furnace	36 per cent.

The Diffusion Flame System.

The " Diffusion Flame System " was primarily designed to produce a long flame of high heat-radiating value. Flames up to 80 ft. in length can be obtained. It is actually a closely controlled system of incomplete combustion in the first instance, complete combustion being obtained finally at a point in the furnace where surface damage to steel is at a minimum owing to its low temperature. The furnace itself is similar in design to the billet furnaces previously described, and differs only in the type of burner and its degree of control.

The burner essentially consists of a series of horizontal rows of gas orifices placed concentrically in air orifices, the bottom row consisting of gas orifices only. The air is preheated by recuperation, not to the maximum point theoretically possible, but to a temperature which causes the density of the air entering the furnace to be the same as, or slightly less than, the density of the gas used. This has certain very important practical aspects, when taken in conjunction with the use of gas and air at equal pressures at the burner. Mixing of the air and gas takes place principally by slow diffusion, and not by turbulent mixing. The diffusion is assisted by having the gas and air at similar densities. The gas and air flow along the length of the furnace in parallel streams, combustion taking place at their lines of junction. The partial combustion obtained gives rise to incipient carbon formation with resulting high luminosity. The number of parallel zones of incandescent carbon particles gives a luminous

PLATE 2.—*View of continuous furnace for heating long boiler tubes for reduction in diameter by passage through a series of graded rolls. The furnace is in a series of sections, each separately heated by burners firing tangentially in the combustion chamber. The tubes are supported on water-cooled rollers placed between each of the furnace sections. The tube passes along the furnace and becomes progressively heated to the correct temperature for rolling, passes through the rolls, and thus along a trough of pulleys to a mechanical loading platform. From the charging to loading the process is mechanically continuous. This furnace is unique, being designed by members of the firm using it and is the only one of its kind in the country. The burner equipment is the automatic gas/air proportioning system supplied by British Furnaces, Ltd., Chesterfield.*

TABLE III.—*Test on Slot Forge Furnace, equipped with S C. Diffusion Flame Burners.*

Furnace.	
Inside dimensions . .	65 in. wide by 30 in. deep by 24 in. high
Slot ,, . .	54 in. by 3 in. high
Operation of Furnace.	
Furnace heated by diffusion flame burners and used for heating bars for forging into motor car axles.	
Bars . . .	1⅛ in. diam. by 34¾ in. long, weighing 9¾ lbs. each.
The bars are heated for a length of 24 in., rolled to a slight taper, reheated for about 8 in. and the ends upset. Forty bars constitute one heat, half the bars being rolled, then reheated while working the remaining 20 bars. As the reheated bars are upset they are replaced by new material.	
Results.	
Actual rate of heating	1,055 lbs./hour
(*a*) Furnace hearth 24 in. by 54 in. .	9 sq.ft.
Rate of heating	117 lbs./sq.ft./hour
(*b*) Hearth area covered by work . .	8⅓ sq.ft.
Rate of heating	126 lbs./sq.ft./hour
Average gas consumption	4 cu.ft. of 500 B.Th.U. gas per lb. of metal.

NOTE.—The actual thermal efficiency of this furnace fitted with diffusion burners is not high, but still is good for such a cycle of operation.

The practical process value, however, more than compensates for this lower thermal efficiency, since scaling of the metal is so low that rejections due to burning are almost eliminated, no pickling is required, and machining costs are reduced by 25 per cent.

belt of flame with a heat radiating propensity approaching black-body conditions, for any desired distance at the bottom end of the furnace. The rate of diffusion is such that almost complete combustion results by the time the gases reach the cooler end of the furnace.

The type of flame is not of such high calorific intensity as that produced by complete short-flame combustion, but is capable of transmitting its heat at a higher rate owing to its having greater radiating power than a non-luminous flame. Consequently the temperature difference between the desired final temperature of the steel and the source of heat does not need to be so high as when short flame combustion is used. Naturally, this limits to a large extent the danger of burning or over-heating the steel. But in addition to this, a further important practical asset arises. The hearth of the furnace is covered with a belt of unburned gas at the hottest end, where danger to scale formation is most likely to occur, and with a belt of products of incomplete combustion containing excess gas towards the cooler end of the furnace. Such an atmosphere limits the danger of scaling to very small dimensions. The free air in the furnace tends to remain along the top of the furnace arch, and consequently does not come in contact with the steel. The efficiency of such a furnace, although being of a fairly high order, is not its only desirable practical attribute. Its ability to prevent excessive scale formation on the billets during heating not only saves metal, but adds considerably to the speed and ease of rolling, and to the quality of the finished bar. This type of furnace is proving popular in the United States and in Germany, and with the larger quantities of cheap town gas now becoming available in this country, will become more widely adopted. In Germany such furnaces are used in conjunction with heat resisting metal recuperators, and burners of even more particular design, in order to obtain greater control of distinct zone temperatures along the length of the heating chamber.

(*b*) BILLET-HEATING FOR FORGING AND DROP STAMPING.

Furnaces for the heating of billets for forging and drop-stamping are seldom of a continuous type. They are

usually " in and out " furnaces, largely because of the fact that a great variety of shapes and sizes of articles are dealt with. Such furnaces require to be as efficient as possible, and capable of rapid temperature changes when desired. For repeat work, where they can be run continuously for long periods, use of recuperation is a big advantage, and furnaces designed to this end are in everyday use, mostly with brick recuperators, and separate gas and air ports. Rapid heat transfer from the luminous flame obtained results, and the rate of heating for forging is not limited by metallurgical requirements.

TABLE IV.—*Test on Regenerative Furnace for Drop-Stamping Cranks.*

Time.	Gas Rate per Hour.	Output of Cranks, 71 Lbs. Each.
1	2	3
7.30 a.m.	Start	..
8.30 ,,	1,800	15
9.30 ,,	1,800	23
10.30 ,,	2,070	19
11.30 ,, to	2,280	17
12.0 noon	..	2
1.0 p.m. to	..	..
1.30 ,,	2,260	6
2.30 ,,	2,150	20
3.30 ,,	2,390	20
4.30 ,,	2,100	24
9.0 ,,	2,200	..
9.30 ,,	2,520	1
10.0 ,,	2,280	11
10.30 ,,	2,180	11
11.0 ,,	2,220	9
11.30 ,,	2,560	..
12.0 midnight	2,240	27
Average rate per hour lit from 7.30 a.m. to 12 midnight	2,197	Total 205

Consumption of Gas per Lb. of Output.

7.30 a.m.–12.0 noon	1·47 cu.ft.
1.0 – 5.0 p.m.	1·56 ,,
9.0 p.m.–12.0 midnight	1·67 ,,
Per hour worked	1·56 ,,
Per hour lit	1·69 ,,

Total Gas Consumption and Output.

24,540 cu.ft. . . . . 14,555 lb. steel

Temperatures.		*Thermal Efficiency.*
Maximum	1,360° C.	
Minimum	1,275° C.	43·8 per cent.
Average	1,306° C.	

Heating for forging may be done as rapidly as is consistent with good hammer operations. But here again, too great a flame temperature causes serious damage to steel, since it is at forging temperatures that scaling and decarburization of steel become very pronounced. The temperature is so near the fusion point of scale, that lack of temperature control often results in burning of steel. In passing, it may be mentioned that it is the very high flame temperature produced by oil that mitigates against its successful use for this purpose. In forging, therefore, flame contact should be avoided. The furnace temperature should be so controlled that at no time and in no place in the furnace will the burning temperatures of the steel be exceeded, since the detection of forgings damaged by burning is very difficult if the fault fails to show at the surface. The operation of forging furnaces with an excess of gas, producing a somewhat reducing atmosphere, will tend to prevent burning.

Satisfactory as modern gas-fired forging furnaces are, there is still room for improvement, particularly with regard to prevention of surface damage to steel. Small furnaces for " jobbing " work, incorporating diffusion-flame principle and use of metallic recuperators, would assist materially in the still wider application of town gas for forging small articles of steel.

For the heating of steel for drop-stamping, some of the finest furnace equipment, using town gas, is available, and is used, to-day.

Such furnaces usually embody brick regenerator systems or heat storage equipment, the alternate heating up of the chequer-work by flue-gases and absorption of stored heat by air for combustion usually being done at stated intervals. Simple manual reversal, or mechanically operated reversing apparatus can be employed. The salvage of the heat in the waste gases by standard furnaces designed on these lines gives excellent operating efficiencies on long period working. Here again the highly radiant type of flame, so arranged as not to come in direct contact with the steel being heated, assists in giving rapid heat transference.

(*c*) Sheet Heating.

Sheet Heating is one of the old processes for which it was deemed essential to have black smoke in the heating chamber. The reason given for the presence of smoke or carbon particles have been various, but the object at any rate was primarily to preserve what is termed the " finish " of the sheet. When a sheet is rolled to a particular gauge, it is covered with a very adherent form of scale—rolling scale. This scale is very thin, and blue-black in appearance, and it is desirable to preserve this appearance after normalizing to remove rolling strains. The temperature used for normalizing such sheets is low, but sufficiently high for further oxidation by free air to take place, so it is a necessity rather than a virtue, that black smoke be present when using solid fuel, when maintaining such a low temperature. The carbon particles further assisted in preventing the " sticking " of sheets, when put in the furnace in piles.

Town gas fired sheet furnaces are in common use to-day, and the sheets have lost nothing of their earlier desirable " finish." In fact, this class of furnace can now be used for certain special steel sheets demanding even closer control of temperature and furnace atmosphere. These furnaces are built on very similar lines to those described for heating for drop-stamping incorporating a similar regenerator system, but usually having a larger working hearth. The method of combustion, separate gas and preheated air, is slightly different. Very incomplete combustion occurs at first, giving a large excess of gas in the working chamber, which decomposes to give rise to smoke—carbon particles—and reducing gases. This atmosphere is similar to that occurring in a coal-fired furnace for the same purpose, but the amount of free air is appreciably less. Those products containing excess gas are further admixed with air, outside the working chamber, the heat thus derived being available for heating the hearth of the furnace, or of increasing the temperatures of the regenerator brick-work, and hence the air for combustion. The efficiency of such furnaces, from a thermal standpoint, is naturally not so high as in drop-stamp furnaces, but from a process point of view they are admirable.

(*d*) Annealing.

With annealing furnaces again, the bogey of black smoke from solid fuel fired furnaces has persisted for years. The annealing of steels is a particularly important process, since the bulk of the steel supplied to tool manufacturers is the starting point of many intricate tools. Reference to certain metallurgical items is unavoidable, if a proper understanding of the difficulties of annealing is to be realized. The annealing temperature of ordinary steels is sufficiently high for damage to the surface of the metal to occur if oxidizing gases are present. This damage is two-fold, scaling of the steel and removal of the carbon in the surface of the steel occurring simultaneously. This latter feature—decarburization—is more undesirable than is simple scale, and unfortunately, when steps are taken in solid fuel open-type furnaces to prevent scaling, the amount of decarburization usually increases. Consequently box annealing, or close annealing, has had to be used, the material to be heated being packed in metal containers along with some material such as charcoal to prevent damage by free oxidizing gases. Since the introduction of gas-fired annealing furnaces, many of these difficulties have been removed. Standard types of open gas-fired furnaces are in daily use, where there is no need to pack the steel in expensive containers, and where the products of combustion containing no free air allow

good commercial results to be obtained at competitive costs.

The interesting subject of bright annealing of steel will be dealt with in the section on furnace control.

(*e*) Heat-Treatment for Hardening.

It is in this field of the application of heat that we have the most varied and difficult conditions with which to contend. In this, one of the final stages of the heating of steels, the greatest care requires to be taken, since the steel has received the major part of its machining or mechanical treatment into its final form. Any surface damage requires to be removed by grinding, machining, sand-blasting or pickling, according to the form of the article, and these operations represent expensive labour, time, apparatus, and material. It is true that the factor of temperature control probably demands the closest attention, since it is this which primarily controls the ultimate service value of a steel article. Exact temperature control is very difficult with solid fuel fired furnaces, and the use of coke hearths for the dual purpose of forging and hardening is much to be deprecated, and is fortunately rapidly disappearing. It is the skill acquired by experience which enables a satisfactory article to be obtained in solid fuel furnaces, and the ability to judge temperatures by eye is being replaced by the use of standard instruments in conjunction with furnaces fired by town gas under properly controlled conditions of combustion. It may be mentioned that the use of electrically heated heat-treatment furnaces enables very close control of temperature to be obtained, but here again attention to temperature control is but one of the vital factors in successful steel treatment. The control of temperatures in gas-fired furnaces, as distinct from instrument indicated temperatures, by electrical or mechanical means, is equally as successful as with electric furnaces, but so far it has not been so fashionable, shall we say, to adopt it to any great extent.

This subject will be dealt with in more detail under furnace control in the final section of the paper.

There are many types of gas-fired heat-treatment furnaces, ranging from single small units such as oven-furnaces and muffles, to large continuous furnaces for mass production purposes. Every type of combustion of town gas is used, depending upon the temperature and distribution of heat required. Natural draught, gas and air under low pressure, gas and air at high pressures, and high pressure gas, are used in many types of industrial burners. Most have for their object maximum burner efficiency coupled with furnace designs to give maximum furnace efficiency. There is little purpose in describing the common forms of heat-treatment furnace, but one or two special process furnaces may be mentioned with advantage, since they have taken no small part in developing the fabrication of certain forms of steel, and of developing mass production systems.

(*i.*) *The Continuous Furnace.*

The ability to maintain an even or uniformly graded temperature in a long heating chamber has enabled mechanical production for heat treatment of steel articles to be carried out on particularly economical mass production lines. The use of heat resisting belt or chain conveyors suitably designed to hold particular shapes of tools to be treated, passing through the furnace at suitable rates to allow the proper temperature to be reached, and maintained for the necessary period makes possible the production of uniform articles continuously. As the conveyor leaves the furnace, the heated articles fall off into a suitable quenching medium, usually oil, water or brine, often without coming into contact with air. The type of atmosphere in the heating chamber can be varied over wide limits, according to the type of steel and temperature required for its hardening, and the tools consequently require the minimum amount of subsequent work to render their " finish " suitable for marketing.

Plate 3.—*View of magnet heat treatment shop fully equipped with gas-heated furnaces, made by Incandescent Heat Company, Ltd., Smethwick, and Brayshaw Furnace and Tools Company, Ltd., Manchester.*

In certain instances, such as safety razor-blade and small diameter wire manufacture, the use of a refractory or heat resisting steel muffle purged with raw gas gives excellent commercial results. The low temperature used, the short heating period, and the effect of the raw gas purge, results in a perfectly bright article, requiring no subsequent cleaning. Over 90 per cent. of the safety-razor blade manufacture is done in such gas fired continuous furnaces.

For the many heat treatment processes required in the manufacture of steel wire, such as annealing, normalizing, lownealing, highnealing, pearlitizing, " patenting," &c.,

gas-fired continuous tube or open-type furnace lend themselves admirably, principally because of the accurate control and grading of temperature possible.

Continuous furnaces for steel strip of special alloy steels such as stainless steels are widely adopted for similar reasons, and because they lend themselves admirably to the other essential features such as atmosphere control, continuous de-greasing, quenching, and where necessary simple or electrolytic pickling.

The more recent adaptations of gas-fired furnaces for these special steels and special forms of steel will be detailed later.

Of recent years town gas has been used in rapidly increasing quantities for the heat treatment of very heavy castings, and forgings, and with the introduction of still cheaper town gas, this phase of its industrial application is likely to increase even more.

The heating by special methods of large gun-tubes, projectiles, and armour plate, and for large crankshafts is carried out eminently successfully by suitable methods of applying town gas under very precise conditions of temperature control.

(*ii.*) *Tool Heat-Treatment Furnaces.*

It is in this field that the varied methods of adaptation of town gas to the production of controlled heat are most widely used. The variety of tools manufactured to-day is such that the design of the furnaces is primarily controlled by the shape of the tool itself, and by the rate of production required. The necessity of hardening only part of a tool, say the edge in the case of machine knives and scythes, the cutting part of a twist-drill, reamer, or hob, and not the shank, the face of a die and not the back, the teeth in flexible backed hacksaws, and the blade of a knife and not the bolster, makes demands upon furnace construction and design which necessitates very careful systems of heating. These difficulties, coupled with the necessity of attention to temperature and atmosphere control, are such that in many cases the flexibility of town gas makes its use preferable to any other form of fuel. Many furnaces for these purposes are of unique design and do not appear in trade catolgues, but furnace builders show enterprise which is appreciated in meeting special demands.

For many purposes, the use of indirect heating by means of salt-baths and lead baths is admirable. A bath of salts maintained in a state of fusion at the proper temperature by a natural draught burner, or by composite burners, allows great rapidity of heating, and where temperature indicating or controlling apparatus is incorporated, the danger of overheating is eliminated.

In addition, only that part of a tool requiring to be hardened need be immersed. A further important feature is that the danger of surface damage by scaling or excessive decarburization is avoided, and even when the tool is taken out of the bath, the coating of salts remaining on it protects it from the action of air before quenching. These baths are widely used for carbon steels in the forms of twist-drills, reamers, taps, milling cutters, files, cutlery, and small intricate tools, but their use is confined to processes where the temperature is usually not higher than 850° C. Salt baths of suitable composition are equally successfully used for tempering of steels. Lead baths are used for similar purposes, and are preferred in the case of files and certain forms of heavily cut tools.

Salt baths have been used for high speed steel tool hardening, but experience has shown that not only is the use of salt baths at very high temperatures expensive, especially in replacement of pots to hold the salts, but that the temperatures attainable are not sufficiently high for correct heat treatment purposes.

A further essential for the correct heat treatment of tools is tempering, or "drawing," as it is commonly termed. It is still common practice to give insufficient attention to this metallurgical requirement, but experience has shown conclusively that the use of the proper temperature and time of heating adds materially to the value of the tool. The method of heating to a desired surface colour of the metal, known as colour tempering, is being replaced by methods employing accurately known temperatures. The use of salt baths has already been mentioned, but heated oil baths, temperature controlled oven and muffle furnaces, and hot-air furnaces are also used extensively. The hot-air system has been successfully carried out by electrically heated circulation furnaces and an equally successful gas-heated air circulation furnace would be an advantage. It is very probable that such a furnace will be available soon.

With regard to high speed steel, this use of a further heat treatment after hardening is particularly important, and it should not be confused with simple tempering.

COMPARISON OF OIL AND GAS COSTS FOR HEAT TREATMENT.

Table VI. is a record of comparative tests of oil and gas as fuel for heat treatment of steel parts.

Furnaces No. 1 and No. 2 are oil fired, while Furnace No. 3 is gas fired.

In comparing the two systems of heating the variables such as the shape and weight of the charge, the time taken to charge and discharge, the rate of heating up and the period of "soaking" the charges have considerable effect on the cost of individual charges, and it is only by averaging a large number of charges or heats that reliable comparisons were obtained. These are shewn at the end of the schedule of tests.

TABLE V.—*Empty Furnace Test.*

Fuel	Oil.	Gas.
1	2	3
Time required to raise furnace from 310° C. to 850° C.	8½ hours	6½ hours
Amount of fuel required	93·1 galls.	23,760 cu.ft.
B.Th U. required (in millions)	16·18	11·88
Cost—oil at 58s. 6d. ton, gas at 1s. per 1,000 cu ft.	22s. 10½d.	23s. 9d.
Cost per hour lit	2s. 8¾d.	3s. 7¾d.
Period of maintaining at 850° C.	5 hours	3 hours
Fuel required per hour	5·0 galls.	1,120 cu.ft.
Cost of fuel per hour	1s. 2¾d.	1s. 1¾d.

To compare the two systems of heating in another way, the consumption of costs were obtained when an empty furnace was raised from 310° C. to 850° C. and maintained at 850° C.

SUMMARY.

1. Under works conditions the cost of heating by town gas is appreciably less than heating by oil, with gas at 1s. a 1,000 cu.ft. and oil at 58s. 6d. a ton.
2. A gas-fired furnace can be raised to 850° C. more rapidly than can a similar oil-fired furnace, and the cost of maintaining this temperature is slightly less with gas than with oil.

CONTROL OF CONDITIONS IN A FURNACE.

The physical properties of steels of all kinds depend upon the use of the precise temperature at every stage in their passage from the ingot to the final fabricated form, for metallographic reasons not necessary to describe in detail in this Paper. The temperature used at any stage is dependent on several closely related factors, notably the composition of the steel, the re-heating or heat-treatment process being performed, and the desired distribution of the constituents of the steel for the physical properties being produced. These temperatures vary from about 200° C. for tempering, to 1,250° C. for rolling, and as high as 1,400° C. for certain types of hardening.

TEMPERATURE CONTROL.

It is emphasized that if town gas is to be used to the extent it is capable of, in steel treatment, temperature control apparatus is essential. Fortunately this need for accurate temperature control is being more generally appreciated by the more progressive steel manufacturers of to-day, and its greater adoption in the future in gas-fired

TABLE VI.—*Comparative Tests of Oil and Gas as Fuel for Heat Treatment of Steel Parts.*

OIL BURNER—No. 1 FURNACE.

Heat.	Material.	Weight. (Cwts.).	Furnace Temperature. After Charging.	Furnace Temperature. Final.	Furnace Temperature. Increase.	Hours in Furnace.	Oil. Used.	Oil. Per Hr. Lit	Oil. Per Cwt.	Cost. Per Cwt.	Cost. Per Hr. Lit.	Output. Cwts. per Hr.
1	2	3	4	5	6	7	8	9	10	11	12	13
			° C.	° C.	° C					d.	s. d.	Cwts.
1	Gears	22·32	540	690	150	20¾	44·0	8·00	1·98*			
Empty	Furnace	..	380	495	115	4¾	43·5	9·16	.. *			
2	A. hubs	4·91	420	690	270	4½	40·5	9·34	8·27*			
3	A. hubs	4·91	580	680	100	2½	17·0	9·71	3·46			
4	Forks	7·14	595	620	25	3½	7·0	3·65	0·97			
5	A. hubs	4·91	525	680	155	5	42·5	10·00	8·65			
6	Knuckles	7·50	520	580	60	2½	5·5	9·43	0·73			
7	Levers	9·50	480	630	150	4¼	33·0	7·07	3·47			
8	Std. cranks	6·64	575	675	100	3¾	18·0	5·68	2·71			
9	Std. cranks	6·64	605	670	65	2	15·5	7·75	2·33			
10	Std. cranks	6·64	600	680	80	2	21·0	11·46	3·16			
11	M. cranks	5·625	590	660	70	1⅞	9·0	6·36	1·56			
12	M. cranks	5·625	570	670	100	2½	13·5	6·00	2·40			
9 heats in 55 working hours		65·13	Corrected for meter error				174·0	7·62	2·67	7·88	1 10·5	1·18

OIL BURNER—No. 2 FURNACE.

1	2	3	4	5	6	7	8	9	10	11	12	13
			° C.	° C.	° C.					d.	s. d.	Cwts.
1	Std. cranks	6·64	547	685	138	2¾	30·0	12·00	4·52			
2	Swivels and forks	9·30	580	645	65	2½	15·0	6·42	1·61			
3	Bolts	4·69	580	640	60	1¾	6·5	7·08	1·39			
4	A.E.C. hubs	9·37	535	590	55	3½	10·5	6·30	1·12			
5	Gears	13·00	470	650	180	5	42·5	9·60	3·27			
6	Worm shafts	12·25	530	680	150	4	34·0	8·88	2·77			
7	Worm shafts	12·25	570	680	110	5⅛	30·0	5·46	2·45			
8	F. wheels and hubs	7·50	580	690	110	3⅜	22·0	8·80	2·93			
9	Std. cranks	6·64	595	675	80	3½	28·0	9·12	4·05			
10	A. hubs	4·91	610	680	70	3¼	20·0	7·94	4·07			
11	Std. cranks	6·64	585	670	85	3½	21·0	6·63	3·16			
12	A. cranks	7·32	550	630	80	1½	8·0	9·60	1·09			
13	Std. cranks	6·64	560	670	110	3½	24·5	7·35	3·69			
14	Std. cranks	6·64	570	675	105	3	16·0	8·00	2·41			
15	Std. cranks	6·64	550	680	130	3⅝	29·0	9·65	4·37			
16	Std. cranks	6·64	570	685	115	3¼	20·0	10·00	3·01			
17	Std. cranks	6·64	570	675	105	3¼	20·0	9·24	2·89			
18	Gears	10·27	565	630	65	3⅜	27·5	7·33	2·68			
19	M. cranks	5·625	550	660	110	2¼	26·0	11·55	4·62			
20	M. cranks	5·625	570	675	105	1⅞	16·5	9·43	2·93			
21	M. cranks	5·625	600	670	70	1½	11·5	9·84	2·04			
22	M. cranks	5·625	570	660	90	3	13·5	4·91	2·40			
22 heats 73½ hours		166·48	Corrected for meter error				442·7	8·32	2·66	7·84	2 0·5	2·27

furnaces will be assisted by our closer co-operation with instrument makers, and by our willingness to give practical demonstrations of its technical applications and advantages.

ATMOSPHERE CONTROL.

(1) Gaseous Products of Combustion.

Mention has been made already of the desirability of maintaining correct chemical conditions in a furnace working chamber, and in a few instances the simpler types of atmosphere control and their practical applications have been cited. It has been customary for many years in advocating the adoption of gas for the heating of metals, to enlarge upon its abilities to maintain positive furnace pressures, and to produce products of combustion which prevented excessive damage to steels. These features of town gas have served no small part in increasing its industrial usefulness, but of more recent years the types of steel which have been produced, and the many forms into which they have been fabricated for modern engineering, industrial and domestic requirements, have necessitated far greater attention to methods of heating and processing than has been necessary in the past.

It is for this reason that it has been deemed desirable to discuss in some detail the technical and theoretical aspects of the atmospheres present in furnace working chambers. A proper understanding of the subject may be assisted by reference to the products of combustion of fuels other than town gas, and such reference will at any rate indicate why town gas is rapidly becoming the preferred fuel where considerations of surface effects on metals are vital.

The subject of this section is primarily concerned with the control of the atmosphere present in the working chamber of a furnace in which steel is heated for any of the purposes coming under the general heading of heat-treatment.

As usually encountered, the source of heat is the combustion of a fuel, solid, liquid, or gaseous, and the metal is heated by convection and radiation, or by radiation alone as when a muffle is placed between the metal and the burning fuel. This means that in every case there is present in the working chamber of the furnace a mixture of gases usually referred to as an atmosphere, the effects of which play a very important part in the particular heat-treatment involved.

We may with advantage consider briefly at this stage the compositions of gaseous products of combustion. The old terms of "neutral" oxidizing and "reducing" atmospheres have ceased to have their original definite meaning when viewed in the light of more recent knowledge. Considered from a chemical aspect, a neutral atmosphere, that is one obtained by the theoretically correct amount of air and gas being consumed together, consists of a mixture of CO_2 and H_2O vapour in N_2 with no free O_2 or CO, or unburned hydrocarbons. An oxidizing atmosphere contains in addition free atmospheric O_2 and a reducing atmosphere contains no free O_2, but does contain some CO and unburned hydrocarbons.

Actually it is not often that the analysis itself gives any indication of the amount of H_2O vapour present, and this is usually computed from a knowledge of the composition of the fuel used, or may be determined by a separate aspiration test for water-vapour alone.

The term "neutral" originally implied that a piece of

TABLE VI.—(*Continued*).

GAS BURNER—No. 3 FURNACE.

Heat.	Material.	Weight. (Cwts.).	Furnace Temperatures.			Hours in Furnace.	Cubic Feet of Gas.			Cost.		Output.
			After Charging.	Final.	Increase.		Used.	Per Hr. Lit.	Per Cwt.	Per Cwt.	Per Hr. Lit.	Cwts. per Hr.
1	2	3	4	5	6	7	8	9	10	11	12	13
			° C.	° C.	° C.					d.	s. d.	Cwts.
1	F. wheel covers	7·00	590	680	90	1⅜	4,830	3,864	690			
2	Std. cranks	6·64	600	680	80	1⅝	3,350	3,350	505			
3	Gear fork levers	7·17	600	640	40	2⅜	..	..	..			
4	A. E. C. hubs.	7·50	525	610	85	3	3,370	3,677	450			
5	Gears	11·25	550	658	108	5	7,590	3,504	300			
6	Worm shafts	12·25	520	690	170	3⅝	9,450	3,436	770			
7	Worm shafts	12·25	570	683	113	3½	5,400	3,086	441			
8	Worm shafts	12·25	580	680	100	3	5,590	3,354	456			
9	Std. cranks	6·64	560	700	140	1¾	4,550	3,640	658			
10	Std. cranks	6·64	615	685	70	2	3,820	3,528	552			
11	A. hubs	4·91	620	700	80	2⅛	4,130	3,540	841			
12	F. wheel covers	7·00	575	690	115	2⅜	3,500	3,120	500			
13	A. hubs	4·91	610	670	60	2⅛	3,150	3,150	610			
14	A. cranks	5·86	510	600	90	2⅜	..	..	..			
15	A. hubs	4·91	520	675	155	4⅛	9,180	3,240	1,870			
16	Worm shafts	10·50	590	675	85	3½	5,850	3,052	557			
17	A. hubs	4·91	560	680	1·0	1¾	4,390	3,760	894			
18	A. hubs	4·91	615	685	70	1⅝	3,210	3,504	654			
19	Pivots	15·09	575	650	75	3	4,380	3,504	290			
20	M. cranks	5·625	500	660	160	3⅜	8,950	3,159	1,591			
21	M. cranks	5·625	590	660	70	1⅞	6,160	3,080	1,095			
22	M. cranks	5·625	610	670	60	2¼	4,690	3,127	833			
23	M. cranks	5·625	560	660	100	2	4,920	3,107	874			
24	M. cranks	5·625	550	660	110	1⅞	5,160	3,096	916			
24 heats	72½ hours	180·72					105,620	3,358	584	7·01	3 4·3	2·50

SUMMARY OF TESTS.

Fuel.	Furnace.	Number of Heats.	Hours Worked.	Hours Lit.	Per Cent. of Hours Lit.	Output.	Output per Hours Worked.	Oil or Gas Used.	Oil or Gas per Hour Lit.	Costs.			
										Per Hour Worked.	Per Hour Lit.	Per Cwt. Output.	Per Ton Output.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
						Cwts. Qrs. Lbs.	Cwts.	Galls.	Galls.	s. d.	s. d.	d.	s. d.
Oil	No. 1	16	49	34¾	71	100 1 25	2·05	366·0	10·8	1 3	2 7	10·84	
Oil	No. 1	1	3½	1⅞	56	4 3 18	1·46	21·6	11·8	1 7	2 11	12·98	
Oil	No. 2	1	3⅝	2½	61	4 3 18	1·27	14·8	6·4	0 11½	1 7	8·85	
Oil	No. 1	10	55	23	42	65 0 18	1·18	174·0	7·6	0 9½	1 0½	7·88	
Oil	No. 2	22	73½	53	72	166 1 26	2·27	443·0	8·3	1 5½	2 0½	7·84	
Oil		50	184½	115	62	341 3 21	1·86	1,019·4	8·9	1 4	2 2	8·80	14 8
								C.Ft.	C.Ft.				
Gas	No. 3	15	49½	37½	55	106 2 17	2·15	84,705	3,090	1 8½	3 1	9·53	
Gas	No. 3	24	72½	31½	43	180 2 25	2·50	105,620	3,358	1 5½	3 4	7·01	
Gas		39	122	59	48	287 1 14	2·35	190,325	3,225	1 6½	3 2½	7·96	13 3

metal, particularly steel, heat-treated in such an atmosphere would remain unaltered as to its surface. In actual practice to obtain an atmosphere guaranteed to contain no free O_2 is very difficult, particularly with solid fuels, and to attempt to remove all free O_2 many varied methods have been employed in the practice of heat-treatment of metals.

It is an acknowledged fact that if scaling is to be avoided no free O_2 must be present in the working chamber of the furnace. The many furnaces designed to consume solid fuel and designed to prevent ingress of air from outside by maintaining a balanced draught, or by maintaining a positive pressure inside the furnace or designed to work in such a manner that an atmosphere containing free carbon in the form of smoke, are too well known to require more than mention here. They serve to emphasize the fact that in practice many attempts have been made to guard against the damaging effects of free O_2 in heat-treatment and re-heating processes.

With gas-heated furnaces it is easier to make attempts at atmosphere control. The fuel is in the optimum condition for combustion to take place; it is easily controlled with regard to its pressure and rate of flow, and there are many types of burner in everyday use which allow of exact proportioning of the air and gas to be admitted to the furnace. Many of these burners have separate controls for the gas and air, and in many others the desired air/gas ratio is obtained by a suitable arrangement of orifices and valves under single control. Any desired mixture can be obtained and maintained at any required rate of flow of the mixture. In either case, by separate control or by uni-control, a mixture of gas and air can be obtained, which on combustion results in a neutral, oxidizing or reducing atmosphere, as defined earlier in this Paper. It may be justly claimed that with a gaseous fuel it is much easier to obtain any of these desired atmospheres, neutral or reducing, or oxidizing, than with any other form of fuel.

(2) The Action of Gases on Steels.

It is now proposed to review as briefly as possible the theoretical considerations of the problem of the action of gases present in products of combustion of a fuel on steel at elevated temperatures. Research organizations in this country, on the Continent, and in the United States, attached to steel firms, Gas Companies and Universities have published tomes of information on this subject. Valuable as most of this information may be in certain circles, it has not added very materially to the successful practice of the heat treatment of steels, particularly at high temperatures. Any success which has been met with in the practical application of heat has mostly been made by the men who have it to do in their everyday work in the shop, and so far their results have been largely obtained by the simple expedient of keeping free O_2 out of the working chamber. Their main weapon has been an excess of fuel in the gaseous form, *i.e.*, products of combus-

tion containing an additional amount of unburned gas. Even with these conditions, successful as they have been up to a point, with high speed and alloy steels demanding very high temperatures for their successful heat-treatment, it has not been possible to eliminate the formation of scale and the attendant trouble of decarburization.

We therefore have to acknowledge that even with the so-called " reducing " atmosphere, it has not been possible to heat a piece of steel and obtain a clean, unaltered surface. With steels requiring low temperatures for their heat-treatment, a considerable amount of success has been obtained, but as the temperature for heat-treatment has been raised as steels have become increasingly complex, the troubles due to scaling and decarburization have increased tremendously. It will be advisable then for us to consider the causes of scaling and decarburization, especially at high temperature, when according to accepted ideas of heating in a reducing atmosphere, these troubles ought not to arise.

(*a*) *Scaling.*

Definitions of neutral, oxidizing, and reducing atmospheres have been given earlier in this Paper. *Actually a " neutral " atmosphere is highly oxidizing to steel at elevated temperatures, and a reducing atmosphere is but comparatively less oxidizing.*

Let us consider the " neutral " atmosphere, *i.e.*, one obtained by theoretically correct burning of the fuel, and containing only definite proportions of CO_2 and H_2O vapour according to the type of fuel used. Numerous Research workers have carried out tests on the individual gases found in a neutral atmosphere, and on various combinations of them, and it has been shewn conclusively that both H_2O vapour and CO_2, even when diluted with N_2, will form scale on steel at temperatures above 650° C. As the temperature rises the tendency to form scale increases, until at temperatures above 1,000° C. the weight of scale formed by H_2O vapour alone is considerably higher than that formed by dry air. The most recent work on this part of the subject has been done by Jominy and Murphy working for the American Gas Association at the University of Michigan, and they have shewn that at a temperature of 1,300° C., the weight of scale formed on a unit surface of steel by H_2O vapour alone is more than 100 per cent. greater than that formed when dry air is the surrounding medium. Also the weight of scale formed by CO_2 is slightly greater, under the same conditions of test than that formed by air.

Naturally, the formation of scale is governed by many factors other than temperature and composition of the surrounding atmospheres. The main factors may be summarized as follows:—

(1) Composition of surrounding atmosphere.
(2) Temperature.
(3) Time of exposure.
(4) Area exposed.
(5) Velocity of the gases passing over the steel.
(6) Pressure of the gases.
(7) Composition of the steel.

That scaling increases with increasing temperature has been mentioned, and is well known. That increasing the time of exposure increases the weight of scale is well known, and also that the amount of scale formed is proportional to the area exposed seems a natural supposition. But with H_2O vapour the effect of increasing time of exposure and increasing velocity of the gas is far more pronounced than with either air or CO_2. For example, a piece of steel exposed to the action of H_2O vapour alone at 1,275° C. will form 250 per cent. more scale by weight in 20 minutes than if air were the surrounding medium. Also a second factor, equally important, and in many cases more important, is the fact that scale formed by H_2O vapour is harder and much more difficult to remove than is scale formed by air. Without labouring the point too much, it will be obvious that H_2O vapour alone is a more powerful agent in the formation of scale at very high temperature, say, above 1,100° C., than is air. These results, however, were obtained by using individual gases, and regarding air as an individual gas instead of a mixture of O_2 in N_2. A truer and more enlightening comparison would have been obtained if H_2O vapour and CO_2 had been used in the same proportion in N_2 as in O_2 in air. Results of the latter type have been obtained by Professor Cobb, of Leeds, and his co-workers, and he gave a valuable Paper on the results of his work in 1930. Although Professor Cobb's results were obtained at temperatures less than 1,050° C., the main feature of them was again to show that the scaling action of mixtures of H_2O vapour and CO_2 in N_2 was practically proportional to the water-vapour content.

Having considered very briefly the scaling propensities of the gases present in a neutral atmosphere, we may consider the steps which have been taken to render neutral atmospheres inert as to the oxidation of steel.

The problem has been attacked by many investigators usually working on the lines of how much of a reducing gas such as H_2, CO, CH_4, or unsaturated hydrocarbons is required to render an oxidizing gas such as O_2, H_2O, or CO_2, non-scaling. Many of those workers have found the amount of a composite gas such as town gas required to render the neutral products of combustion of a fuel non-scaling, and the result has been that a very complex mass of data has been collected on the whole subject. Professor Cobb has given the compositions of non-scaling atmospheres producible in this manner, and his findings are so interesting that we may profit by a summary of them:

(1) Exclusion of O_2 is of paramount importance.
(2) More than 0·5 per cent. of O_2 added to a neutral atmosphere results in very much increasing the weight of scale formed.
(3) A small addition of O_2 produces a very marked scaling effect, while a small addition of unburned gas produces only a trifling non-scaling effect.
(4) The following part of the summary is probably the most important, as it shows the difficulty of practical application, and explains why the use of an atmosphere containing excess unburned gas as found in practice, has had but limited success.

The amount of a reducing agent, such as unburned gas, required to prevent scaling, or even to reduce it by half, represents a quantity of potential heat of the same order as that of the fuel required to heat the furnace in the first place.

These results, obtained during years of steady research, along with the results obtained by more recent workers, indicate very clearly why it is that to prevent scaling of steel at elevated temperatures, particularly very high temperatures, is not a simple matter.

Even were it possible from an economic standpoint to prevent scaling by these methods, conditions of practical application impose requirements of furnace construction exceedingly difficult to achieve.

It is convenient at this stage to consider the practical side of the production of neutral atmospheres, from the combustion of the three main forms of fuel, solid, liquid, and gaseous. With solid fuels, it is practically impossible to obtain combustion without excess air. Even when the amount of air used in a solid fuel fired furnace is limited, in an attempt to obtain the atmosphere desired, it is not possible to consume all the O_2, with the result that even when the atmosphere is full of smoke, an appreciable percentage of O_2 remains. That is, an atmosphere containing no free O_2, because of actual conditions of working such as draught arrangements, the use of secondary air, channelling of air through blow holes in the fuel bed, &c., is very difficult indeed to obtain. With coke, burned in the ordinary manner of a solid fuel, the difficulty of obtaining an atmosphere free from O_2 is equally great. In the burning of oil, some measure of success can be obtained in the production of a neutral atmosphere, or even a reducing atmosphere, but when using oil for high temperature work, it is not so easy to remove all the O_2 because of the type of burner which has to be used.

Consequently, the possibility of the formation of scale by H_2O vapour or by CO_2 is tremendously outweighed by the scaling action of the free O_2 which is present in the

atmosphere produced by the ordinary methods of burning coal, coke, or oil.

In an electrically heated furnace, which is virtually a muffle, the muffle is full of air. When the muffle is not closed by a door there is a continuous circulation of air inside the muffle, cold air entering at the bottom of the muffle opening, and hot air passing out at the top of the muffle opening. This is the same, of course, in a muffle fired by any other form of fuel. Even when a door is fitted it is difficult to design it so that it remains air-tight at high temperatures, owing to expansion taking place, and there is always a certain amount of thermal circulation of air. Therefore, as was mentioned earlier in this Paper, the muffle furnace, including the electrically heated muffle, offers of itself no solution to the atmosphere problem. It is becoming common practice among builders of modern electric-radiant furnaces to make arrangements to exclude this air.

In most cases a current of unburned gas is passed into the furnace at such a rate as just to maintain a positive pressure and so exclude air. In others, products of combustion of gas, either the complete theoretical products of combustion or such products with an addition of unburned gas are used.

but it must be emphasized that burner design is of paramount importance. It is not sufficient by any means merely to add a sufficient volume of air for a particular volume of gas, but the burner must be so designed that very intimate mixing of the gas and air takes place before the actual combustion.

With such a properly designed burner, it is possible easily to obtain theoretical combustion of a gaseous fuel and by suitable adjustment to obtain either an excess of O_2 or an excess of unburned gas. With gas as fuel then we are in a position to make use of a real neutral atmosphere, *i.e.*, a mixture of H_2O vapour and CO_2 in N_2. It is a knowledge of this fact that has been used in attempting to get atmosphere control in a gas fired furnace. It is common practice to use a slight excess of gas as a ready and practical indicator that no excess O_2 exists in the furnace atmosphere. In low temperature operations, and when the period of heating is short at low temperatures, this procedure has given satisfactory results, but when working at high temperatures, especially those required for the hardening and heat treatment of high-speed and alloy steels, this elimination of air and use of a slightly reducing atmosphere does not meet the requirements. The result is that in the heat treatment and hardening of

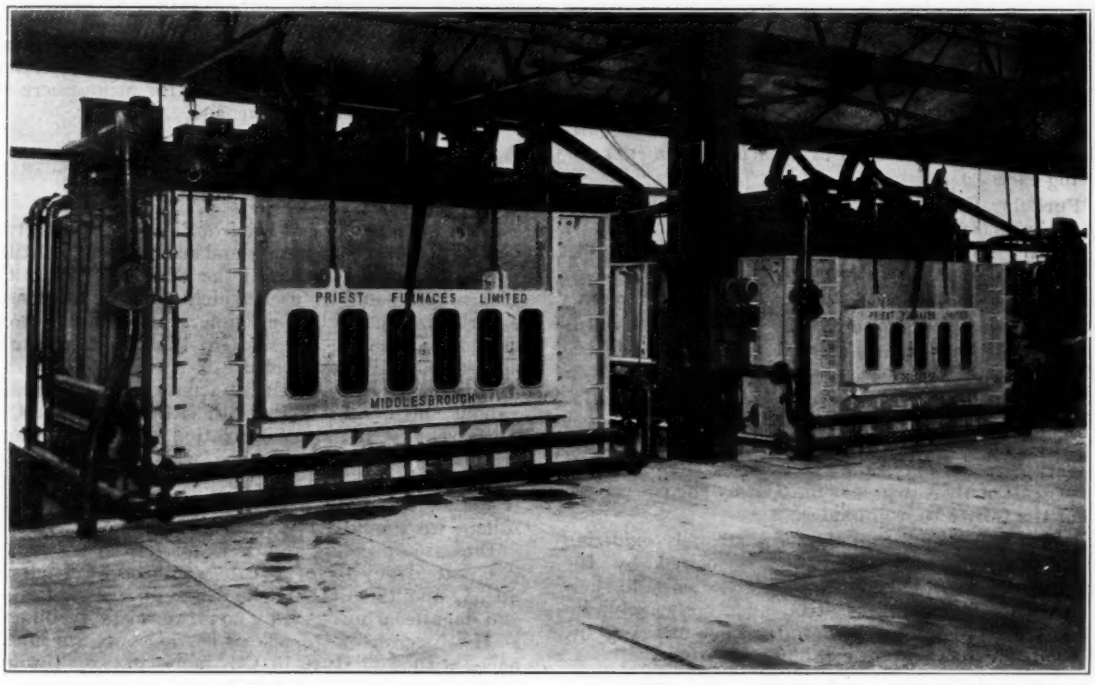


PLATE 4.—*Front view of part of a battery of four sheet heating furnaces. The furnaces are the hand operated regenerative type, air being also passed into the regenerator system to complete the combustion of the gas only partially consumed in the working chamber. Two further batteries of four furnaces each are being installed at the same works. Makers of furnace: Priest Furnaces, Ltd., Middlesbrough.*

Again, a curtain of burning gas may be used to close the mouth of the muffle, and is often used as an addition to one of the other methods mentioned. All these methods are no doubt successful in many instances, especially at low temperatures, say less than 900° C., but for the reasons already outlined, it is not sufficient merely to keep out air, although this helps considerably, but if the air is kept out by a mixture of gases which itself has individual gases present in such proportions as are capable of causing scale formation, complete freedom from scaling cannot be expected.

The case in which unburned gas is used as the medium to keep out air and to prevent scale formation will be considered when reviewing some of the factors of decarburization.

We now have to consider the use of a gaseous fuel as the source of heat. It is acknowledged by men experienced in the burning of fuels that very exact proportioning of air and gas is possible for purposes of combustion,

steels requiring very high temperatures very special precautions have to be taken against the formation of scale. The methods at present used in the trade are too well known to require more than a mere mention here. The use of media to coat the steel; the use of materials in which to pack the steel; the very close timing of the operations, &c., are used, and even with these precautions, it is often necessary to make due allowance in the dimensions of the article being heated to allow of machining and grinding after the hardening process has been completed.

If an atmosphere were known, which could be economically produced, most of these precautions and their consequent expense could be eliminated.

Before leaving the subject of the formation of scale, it should be mentioned that so much research has been done on the equilibria between gases, iron and iron oxides, that it is possible from a knowledge of the composition of a gaseous mixture to predict with certainty whether it will

form a scale or not. Also, knowing the composition of a steel, and the temperature to which it must be heated, it is equally possible to state the composition of the gaseous mixture required to give freedom from scale. But it is not the slightest use knowing these facts unless we can have a practical and economical method of applying them.

(*b*) *Decarburizing.*

We now have to consider the problem of decarburization. Decarburization has been encountered in practically every type of furnace and in many forms of heat treatment. Here again, as in scaling, the subject has been studied from every angle, but the results obtained by the many investigators of the subject have shown a hopeless lack of agreement. In some of the main cases, we have obvious positive results, but in many cases we have completely contradicting results. The gases examined, air, O_2, H_2, H_2O, CO_2, N_2, have all been stated to cause decarburization, and in some cases, the results seem to shew that H_2 does not decarburize. The same factors have influence in this, as have an influence on scaling, that is temperature, time, composition of steel, &c.

It is almost useless to try to give an outline of the many findings of investigators, so rather than give individual results when using certain gases, it may be better to give those facts on which there is most agreement.

(1) Of the gases present in an open fired furnace moist H_2 has by far the strongest decarburizing action. Since moist H_2 is usually present when a furnace is fired with excess gas, it is probably largely responsible for the relatively greater amount of decarburization that is produced in an atmosphere containing excess gas.

(2) Pure dry H_2 is very much less active in producing decarburization than is moist H_2. Small amounts of H_2O vapour, less than 1 per cent., will rapidly increase the degree of decarburization.

(3) Next to moist H_2, CO_2 is the most serious offender.

(4) N_2, when absolutely pure, does not cause decarburization. Ordinary commercial N_2 does cause it.

(5) Scale formed on the surface of steel has a pronounced effect on decarburization, usually by inhibiting it. Decarburization is usually deeper where no scale is formed on the steel. Actually decarburization may take place during the formation of scale, but its degree is masked by the conversion of the ferrite to iron oxides.

(6) It has been found that the more strongly oxidizing the furnace atmosphere, as measured by the amount of free O_2, the less is the tendency to shew decarburization in the steel, and, conversely, increasing the amount of unburned gas increases the tendency to shew a decarburized surface.

From a knowledge of these facts, it would appear that to avoid decarburization, as much as possible, it is necessary to use either a neutral atmosphere or an oxidizing one.

It is very apparent then that in attempting to avoid decarburization by these methods, *i.e.*, using a neutral or oxidizing atmosphere, freedom from scale formation has to be sacrificed. Naturally a balance must exist when there is a minimum of scale formation and a minimum of decarburization, and this balanced atmosphere is apparently a neutral atmosphere.

From a theoretical aspect, it can also be stated that decarburization can only be completely avoided by using a definitely carburizing gaseous mixture. Such gaseous mixtures have been prepared by having perfectly dry mixtures of H_2 and CH_4 in particular proportions according to the carbon content of the steel being heated. Such mixtures have been patented in Germany, but here again it is not usually a practical proposition to obtain such atmospheres and use them. Similar mixtures, *i.e.*, carburizing mixtures, can be obtained by the suitable proportioning of town gas and one of the gases, CO_2, N_2, H_2, natural gas, &c., but to make use of such mixtures in the ordinary heat-treatment of steel, apart from actual carburizing, is again very costly.

We may conveniently consider at this stage the use of unburned gas only as the means of preventing the formation of scale. Many heat-treatment furnaces, usually of the type embodying the use of a muffle or sleeve, have a current of unburned gas passed through the muffle to replace air, and to prevent its re-entry. In many cases where the heating operation is done at a fairly low temperature, say less than 800° C., and when the period of heating is very short, this use of unburned gas gives satisfactory results, but at higher temperatures or when the period of heating is prolonged even at a low temperature, a new condition is set up.

The CH_4 and hydrocarbons in town gas are decomposed by heat, and the higher the temperature the greater and more rapid is this decomposition.

Consider the CH_4. This decomposes to form free C and H_2. Each volume of CH_4 gives two volumes of H_2. This newly formed H_2, along with the original H_2 content of the town gas results in a mixture of gases which is principally H_2. Other secondary reactions take place between the H_2, CO, and CO_2, which result in the formation of H_2O vapour, with the result that at high temperatures the passing of a current of unburned town gas is tantamount to passing a current of moist H_2. Moist H_2 has been declared by *all* the investigators of the subject to be the most serious offender in producing decarburization, and so, in attempting to prevent the formation of scale at high temperatures by means of a current of town gas is to use almost perfect conditions for the production of decarburization. Naturally then this is a serious matter for consideration in using unburned gas for atmosphere control in an electrically heated furnace.

(3) The Practical Production of Neutral Atmospheres.

Having given a very brief outline of the closely allied troubles of decarburization and scaling, we are still faced with a practical solution of the problem. What type of atmosphere could be used which would neither scale nor decarburize at any of the temperatures ranging from that used for annealing purposes to that used for hardening high-speed and alloy steels?

Consider again the neutral atmosphere containing H_2O vapour and CO_2 in N_2. Both H_2O vapour and CO_2 will cause scaling and decarburization. The addition of a small amount of unburned gas, while limiting the amount of scale slightly, increases the amount of decarburization. If we could remove the H_2O vapour from such an atmosphere we should have removed the most serious agent in the case of scaling and decarburization.

The tendency to form scale would be tremendously reduced, and the CO_2 alone, although it does form scale, and does decarburize, is by no means as powerful an agent as H_2O vapour or O_2. Tests carried out in a muffle furnace, with a mixture of CO_2 in N_2 passing through the muffle, gave excellent results at low temperatures, and far better results than are obtained in standard practice at high temperatures. A mixture containing CO_2 in N_2 with only a very small percentage of H_2O vapour can be obtained by the simple method of cooling the products of theoretical combustion of gas. The amount of H_2O vapour present in such a cooled mixture is a function of the vapour pressure of the H_2O at the lowest temperature reached by the products during cooling, and so is a function of the efficiency of the cooler. It is not difficult to cool sufficiently to have a percentage of H_2O vapour as low as 1·8. Such a mixture of gases in a muffle will have a very much reduced tendency to form scale, or even to decarburize, but at high temperatures such as 1,300° C. this mixture will form a certain amount of scale, due to the CO_2 and to the very small amount of H_2O vapour present. But to prevent these two gases having any scaling action whatever, and furthermore to prevent them from removing carbon from the surface of steel, requires but a very small amount of unburned gas in addition. Professor Cobb shewed that to render an ordinary neutral atmosphere non-scaling, it required the addition of very large amounts of unburned gas, owing principally to the high H_2O vapour content of such an atmosphere. When the H_2O vapour is first removed by cooling, however, the amount of unburned gas required is exceedingly small.

and very fortunately indeed in practice the amount required *decreases* as the temperature of the operation increases.

This is a particularly important point. It has already been stated that the simultaneous complete prevention of scaling and decarburization is not a simple matter, but by the removal of H_2O vapour from neutral products of combustion, *followed* by the addition of unburned gas, the chemical reactions between the gases at elevated temperatures give ratios of the resulting gases that are in equilibrium not only with the iron in the steel, but also with the carbon and complex carbides. Variation of the proportion of cooled products of combustion to unburned gas added enables such mixtures of gases to be obtained in a furnace, as are in similar equilibrium for most steel compositions, at any temperature being used. The reason for the inability of a simple non-scaling atmosphere, *i.e.*, one of neutral products of combustion *plus* excess gas, to prevent decarburization at high temperatures, is that the ratio of CO/H_2 is too low. At low temperatures, say, less than 850° C., the presence of undecomposed CH_4 has an influence on the ratio of CO/H_2, and on its action on steel, such that the use of excess gas in products of combustion can quite satisfactorily prevent surface damage.

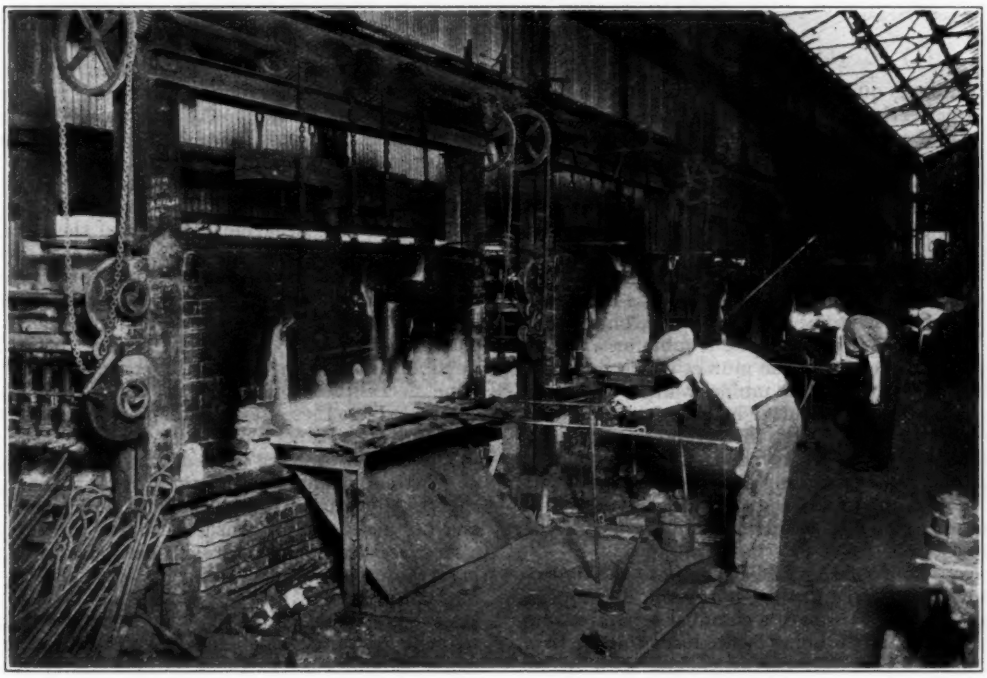


PLATE 5.—*View of part of battery of sixteen furnaces in one works for all types of forging and drop stamping. The furnaces are of the hand operated regenerative type. One furnace was initially installed for test purposes, the test resulting in the immediate placing of an order for fifteen additional furnaces. These have been in use nearly six years, and except for patching of the floors, have cost nothing for repairs. Makers of Furnace: Davis Furnace Company, Ltd., Luton. Type: Davis "Revergen."*

Here again, this is only true where the period of heating is short. Recent research work carried out in the United States has shewn the desirability of having as high a CO content as possible, to prevent scaling, but the practical methods advanced for this purpose are such that the proportion of H_2 also present, although assisting in the elimination of scale, is bound to remove carbon from the steel. It may be said therefore, that at very high temperatures, or for very prolonged heating, no system of practical combustion of town gas is capable, of itself, of preventing both scaling and decarburization.

A practical example will indicate what is meant. One process advocated for prevention of surface damage to high speed steel at 1,300° C. recommends the use of equal parts of gas and air. The ratio of the resulting products of reaction, with a normal town gas, are such that scaling is prevented. But the amounts of H_2 and of H_2O vapour present are in such excess of the CO present that decarburization is unavoidable, even for short heating periods. It may be said, however, that the higher the CO percentage of the raw gas the less is the damage to steel likely to be by this process.

By the removal of H_2O vapour from products of complete combustion, and the subsequent addition of raw gas, the chemistry of the reactions taking place is similar to that which has just been described, but the ultimate ratios of the gases produced are very different. At high temperatures the amount of CO produced is much in excess of the amount of H_2 present; the amount of H_2O present is very small, and the amount of CO_2 present is also small. The result is that the predominating gases capable of chemical reaction which are present are CO and H_2. Both these gases prevent scaling. CO is a carburizing gas, and H_2 is a decarburizing gas. It is natural then that some suitable ratio of the two exists which will be in equilibrium with the carbon in steel, and which will neither decarburize nor carburize. A further point which assists this particular process is that the partial pressure of the active gases present is much lower than the partial pressure of the gases produced by controlled systems of combustion or reaction of gas and air.

This cooling of waste gases and subsequent addition of unburned gas constitutes the basis of one of the most recent systems of complete atmosphere control for steels, especially at high temperatures.

PRACTICAL APPLICATIONS OF ATMOSPHERE CONTROL.

The discussion of the chemistry of products of combustion, complete or incomplete, and the actions of individual gases and mixtures of gases on the constituents of steels at elevated temperatures, naturally demands a description of some of the more important processes carried out in the steel trade embodying the use of atmosphere control. These processes may be roughly divided into two kinds, the first being concerned with the minimizing of surface damage and the second with the complete prevention of surface damage.

Reference has already been made to some of these processes. The re-heating of billets for rolling, forging, and

drop-stamping; the normalizing of steel sheets; commercial annealing of bars in open furnaces; heat-treatment for hardening of plain carbon steels and steels demanding low temperatures, and the " patenting " of steel wire, are some of the everyday heating processes which can be successfully carried out in gas-fired furnaces operating with a positive internal pressure and excess of unburned gas. The reheating processes are usually only concerned with the prevention of excess of scale, since decarburization at this stage is not particularly serious. The annealing, normalizing, and hardening processes are concerned with prevention of both excess scale and excess decarburization, and while hardening is satisfactory, due to the short period of heating—annealing—a long period process is usually not quite so precise.

Processes for Prevention of Surface Damage.

It is in this field that atmosphere control is carried out with rigid attention to all the factors concerned. The prevention of surface damage is not necessarily merely to reduce subsequent costs for removing damaged metal, or of saving metal, but is often primarily concerned with the processing of the steel to give it desired physical properties. Such processes are in fact of recent origin, and have been developed because of the atmosphere control possible with town gas.

(*i.*) *Bright Annealing.*

Bright annealing is quite distinct from ordinary annealing, in that a perfectly clean and bright surface of metal is desired. In the case of mild steels in the form of strip, wire, fine gauze, stampings for assembling, &c., it is customary to use a muffle furnace, and to have a current of raw gas passing through the muffle. The low temperature required for this operation, the comparatively short period of heating, and the possibility of a continuous process being used enabling the steel to be cooled in a continuation of the muffle also gas-filled, enables a very clean surface to be obtained. The one serious objection to the use of raw gas is the trouble arising due to deposition of free carbon in the muffle, which demands fairly frequent cleaning of the muffle walls. To avoid this the gas is often passed through heated metal tubes packed with steel turnings, where the carbon due to cracking remains, and a H_2 rich gas passes into the muffle. Also the possibility of carburizing or of decarburizing the steel arises, depending upon the carbon percentage of the steel, and consequently upon the temperature of the operation.

In such cases it is customary to decompose the hydrocarbons in town gas by controlled pyrogenic decomposition. The gas is passed through a chamber separate from the furnace, the chamber being heated separately to a particular point. The chamber is packed with nickel sheets or turnings to enable equilibrium to be attained quickly. The temperature used, the area of contact with the nickel and the rate of flow determines the amount of decomposition of the hydrocarbons. These factors are dependent upon the carbon content of the steel to be heated, and an equilibrium ratio of H_2 to CH_4 in town gas can be obtained which will neither decarburize or carburize. Practical appliances for this process have been in use in Germany and the United States for some time, and less precise appliances are in use in this country. The production of suitable H_2/CH_4 ratios by this method is extensively done with natural gas in the States.

With special steels such as stainless and low nickel chrome steels in the form of strip and wire, bright annealing requires different types of atmosphere, since the chemical composition of the steels is not like that of carbon steels. Some of these steels are even treated with good results in air alone. Each manufacturer has his own particular system of atmosphere control which is often closely guarded, and in most cases even such annealing is followed by acid-pickling and scrubbing to some degree. More recently the bright annealing or heat-treatment of stainless steel strip has been done successfully in continuous furnaces using cooled products of combustion with the addition of suitable amounts of unburned gas. In this case waste gases are withdrawn by a fan from a suitable place in the flues, cooled in air-coils to room temperature and passed through a system of pipes round the mouth of the muffle and into the muffle. The volume of cooled products used maintains a pressure in the muffle and excludes air. The amount of unburned gas added then depends upon the composition of the steel being heated. For stainless steels the use of products of combustion containing excess gas is of no avail. It is better, where conversion of an existing furnace cannot be carried out, to use excess air instead of excess gas, since it leaves a harder gloss on the metal after pickling. As yet there is no process on the market which will eliminate pickling of stainless steel strip.

(*ii.*) *Bright Hardening of Carbon Steels.*

The bright hardening of carbon steel tools and parts is done in atmospheres of raw gas quite satisfactorily. It is usually done where the process is continuous, as in razor strip hardening, or where large quantities of very small articles such as needles, pen-nibs, hackle-pins, intricate assembly parts, &c., can be heated in packed tubes purged with raw gas. In some cases sufficient excess gas in products of combustion gives excellent results.

(*iii.*) *Hardening of High Speed Steels.*

It has been customary since the advent of high-speed steels to regard their satisfactory hardening as being particularly exacting. The composition of these steels is such that very high temperatures are required, of the order of 1,300° C.-1,350° C., to obtain the cutting value attributable to such steels. It will be apparent for reasons already given, that simple means such as the use of raw gas or products of incomplete combustion have but little success in this field of heat-treatment. The former causes excessive decarburization, and the latter both decarburization and scaling. The initial cost of high speed steel, and the expensive machining to fabricate it into cutting tools such as twist drills, reamers, taps and dies, milling cutters, broaches, lathe turning tools, hacksaws, chasers, &c., make it essential that as little damage as possible be done in the heating process. Any damage done necessitates grinding and sandblasting to re-form cutting edges, these items adding considerably to the cost of a high speed steel tool.

The use of what are termed " Balanced Atmospheres," as distinct from " Neutral " or " reducing " atmospheres, by proportioning cooled products of combustion and unburned gas in consideration of the composition of a steel and the temperature of heating results in eliminating the damage to the surface of the metal. No decarburization occurs, and not more than $\frac{1}{10.000}$ of inch of scale. Consequently no allowance need be made for subsequent grinding, which results in considerable saving of metal, labour charges for grinding, and cost of grinding wheels. These items, however, are by no means the only advantage of such atmosphere control. It has been shewn in actual works practice that tools treated under correct atmosphere controlled conditions have a much longer cutting life than similar tools treated under ordinary conditions. There are very definite physical and metallurgical reasons for this improved quality.

The quality of a steel article depends primarily upon its internal structure and not merely upon the type of surface it shows. This quality is a variable function of the type of steel, the temperature used, the time of heating, the method of quenching, &c. For any one type of steel and method of quenching, the remaining variables are time and temperature. The very close attention to the period of heating in the trade is well known. Even seconds are considered. The temperature too is usually recorded or indicated on an instrument of proved merit. The need for these very careful methods is to render the physical structure of the steel optimum for the particular purpose it has to perform. This structure is often judged by the type of fracture shewn by the steel, or more accurately by metallographic examination. The degree of solution of complex carbides and the size of individual crystals—grain-growth—are usually looked for. The amount of grain-growth and degree of carbides solution are favoured both by high temperature and time of heat-

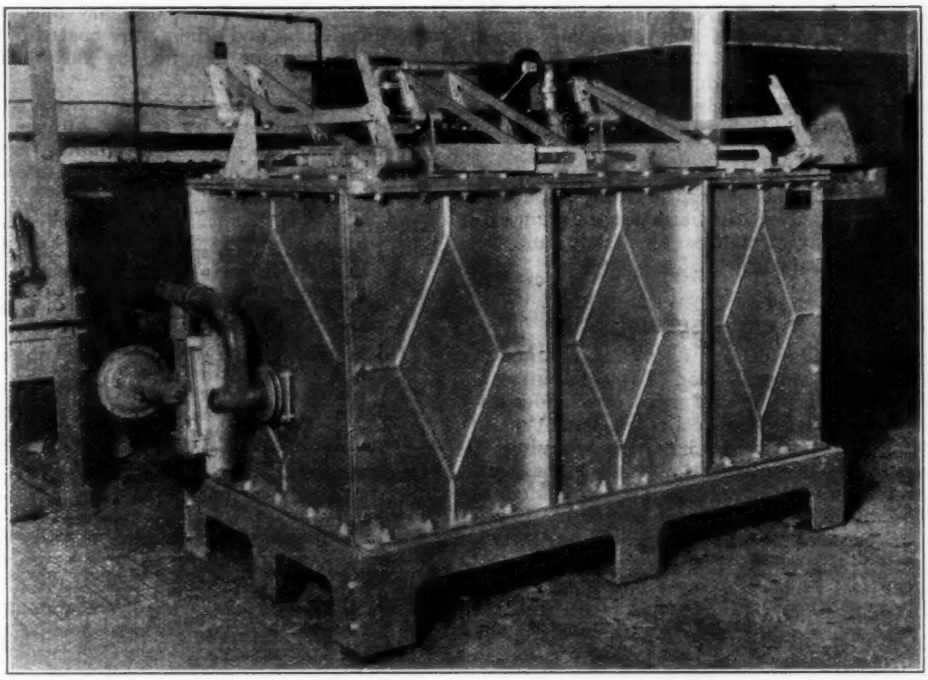


PLATE 6.—*View of twin chambered pit type high-speed steel tool furnace, designed and built by the Sheffield Gas Company, and incorporating atmosphere and temperature control system.*

ing, but as the degree of carbides solution is required to be as high as possible and the amount of grain-growth as small as possible, usually only a suitable average of the two can be attempted.

That is, in actual practice an upper temperature limit has to be used, which will give the maximum carbide solution with minimum grain size. Also the time of heating must be as short as possible in order to minimize the amount of damage done to cutting edges on the steel.

By the use of balanced atmospheres of the type described, these strict practical requirements can be obtained without the close attention to time previously deemed essential. That is, high speed steel tools can be heated under such conditions,

(1) At the usual temperature for longer periods.
(2) For the usual period at high temperatures.
(3) Even for longer periods and at higher temperatures, without excessive grain-growth taking place and without any scale formation or decarburization.

The reasons for the effect of atmosphere control on the internal structure of steels are not readily apparent, and theoretical explanations based on steel thermal equilibrium diagrams have even put forward. It is suggested, however, that the probable reason is more simple.

The control of grain-growth is brought about by two factors:—

(*a*) The gases present in a muffle working chamber are not hotter than the walls of the chamber, whereas in an open or in-flame type furnace, the gases in the working chamber must naturally be hotter than the walls. This means that an article heated by radiant heat in a muffle cannot become hotter than the temperature recorded on the walls of the muffle, whereas an article in an open-type furnace can be hotter than the indicated temperature of the furnace.

(*b*) When oxidizing gases are present in a working chamber, be it a muffle or open-type, the heat of reaction of these gases with the iron in the steel is sufficient to cause excessive over-heating of the article at the surface, with the result that the article may be considerably higher in temperature than is indicated on the walls. This chemical reaction effect, combined with the effect in an in-flame type furnace described in (*a*), results in the steel being heated to a higher temperature than is suggested by an instrument indicated temperature of the furnace.

The " sweating " of high speed steel, or the fusion of the scale, used in normal practice as an indicator, is an example of these two features, since the scale fuses at a higher temperature than that required for correct hardening.

Practical investigation of this phenomenon, where the temperature of a steel was noted by an accurate instrument, and compared with the wall temperature of the furnace, showed that with a temperature of 1,300° C., in an in-flame furnace, the steel rose to 1,340° C. Also in a muffle furnace with correct atmosphere control, the steel did not rise above 1,300° C., the temperature of the furnace. Also, in practice using this type of atmosphere controlled furnace for high speed steel, it is now customary to use longer time at the high temperature demanded by theoretical thermal diagrams, and to obtain the improved quality of tools previously described.

(*iv.*) *Gas Carburizing.*

This does not strictly come under the heading of atmosphere control as usually accepted, but it is a particular advancement of such control for a specific purpose, the case-hardening of mild steel. The possibility of carburizing mild steel by use of raw gas has been mentioned previously under the heading of " Bright Annealing," but properly controlled processes are in use, particularly in the United States, for the case hardening of steels, using town gas suitably cracked and diluted with various gases such as flue gases, chemical dried flue gases N_2, CO_2, air or steam. One method makes use of the alternate action of cracked town gas and steam, and is known as the Intermittent Surge Method. This process is particularly valuable for continuous mass production, and a furnace incorporating it is likely to be installed in this country at an early date.

(*v.*) *Varied Atmosphere Control Processes.*

Reference may be made to a few of the other processes for atmosphere control which are available for the heating of both ferreous and non-ferreous metals.

Cracked ammonia, burned partially and the water

vapour condensed or chemically removed, is suitable for bright annealing or hardening of mild steels and nickel silver, but is expensive.

Methanol vapour diluted with dry products of combustion is used successfully for the bright heating of brasses.

Steam is similarly suitable for the heat treatment of copper.

The process described for the high temperature treatment of high speed steels has been successfully applied to the annealing of nickel silver, the hardening of plain carbon steels, the annealing of stainless steel strip, and the normalizing of stainless steel sheet.

DESCRIPTION OF PLATES SHEWING PHOTO-MICROGRAPHS OF HIGH SPEED STEEL.

The micrographs of illustrations 1, (*a*) and (*b*), and 2, (*a*) and (*b*), shew, at a magnification of 600, the internal structure obtained by heating high speed steel under different furnace conditions. The steel is the same type in each case, being a standard 18-4-1 type, containing 18 per cent. tungsten, 4 per cent. chromium, 1 per cent. vanadium, and 0·7 per cent. of carbon. Steel specimens of the same weight and shape were used in each case. Specimens were heated in an ordinary open-type furnace of modern design, and others were heated in the atmosphere controlled furnace designed by the Sheffield Gas Company.

To emphasize the degree of control over the internal structure obtainable by correct furnace conditions, the specimens were heated for 15 minutes, instead of the two minutes normally employed for specimens of the weight used in these tests.

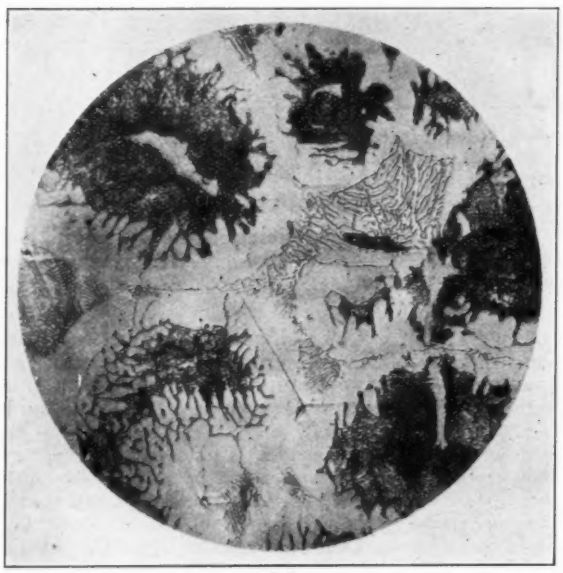
ILLUSTRATION 1.

(*a*) Section of high speed steel heated at 1320° C. for 15 minutes in an open type furnace. Note very excessive burning, large grain size, and undesired eutectic structure. Such steel would be useless for cutting purposes.

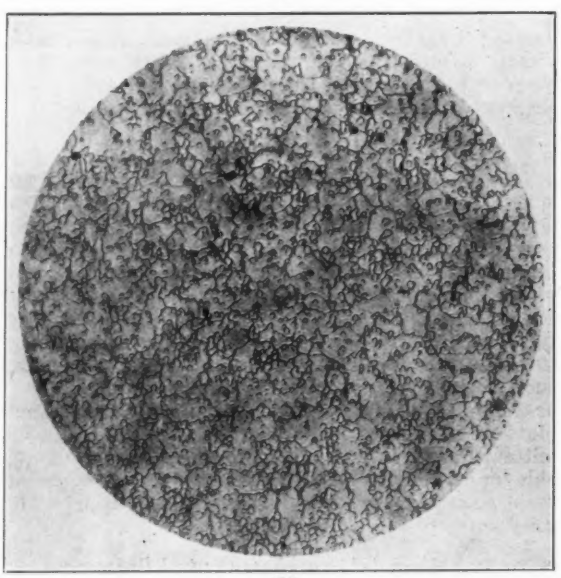
(*b*) Section of high speed steel heated at 1320° C. for 15 minutes in Atmosphere Controlled Furnace. Note complete absence of burning; uniform small size of grain, and optimum degree of carbide solution. Such steel would have excellent cutting qualities.

ILLUSTRATION 2.

(*a*) Section of high speed steel heated at 1300° C. for 15 minutes in open-type furnace. Note large grain

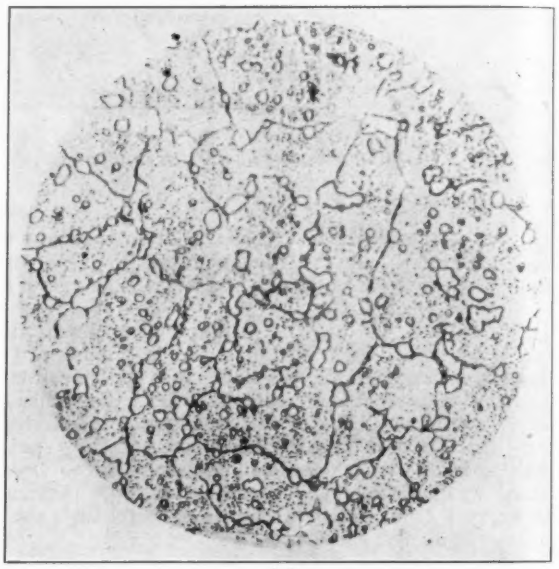


(*a*)

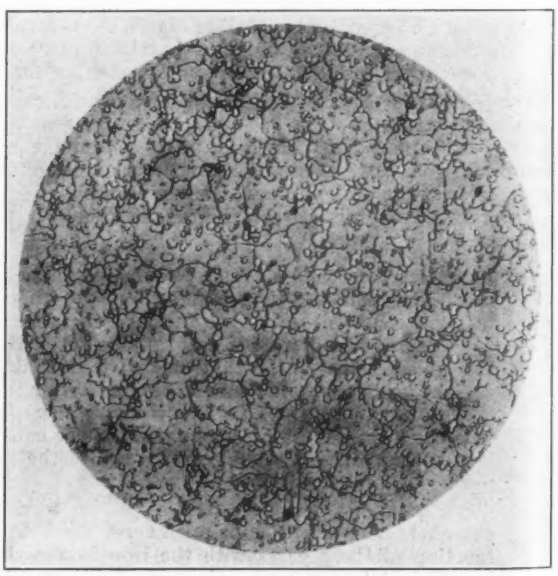


(*b*)

ILLUSTRATION 1.—(*a*) *Section of High Speed Steel heated at 1,320° C. for 15 minutes in an open type Furnace,* (*b*) *Section of High Speed Steel heated at 1,320° C. for 15 minutes in Atmosphere Controlled Furnace.*



(*a*)



(*b*)

ILLUSTRATION 2.—(*a*) *Section of High Speed Steel heated at 1,300° C. for 15 minutes in Open-Type Furnace,* (*b*) *Section of High Speed Steel heated at 1,300° C. for 15 minutes in Atmosphere Controlled Furnace.*

growth size and coagulation of original carbide. Such steel would have but a short cutting life.

(*b*) Section of high speed steel heated at 1300° C. for 15 minutes in Atmosphere Controlled Furnace. Steel almost identical with that shewn in Illustration 1 (*b*).

NOTE.—These sections illustrate the control of grain size possible with a suitable atmosphere, and indicate the prevention of self-chemical heating producing burning and incipient fusion. It is this which produces the prolonged cutting life of a high speed steel tool heated under correct atmosphere control conditions.

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Production of Smokeless Fuel in Chamber Ovens at Medium Temperatures

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[This paper is divided into two parts. Part 1 deals with the evolution of a firebrick retort for the production of low-temperature coke. The flue temperatures in this retort are high, 1,050-1,150° C. at the top, decreasing to about 700° C. at the bottom, but those of the inner surface of the brickwork do not rise appreciably above 700° C. Experiments are described which show that the retort can be made to operate satisfactorily on all types and sizes of coal, from non-caking nuts to strongly-caking slacks The best working conditions are obtained with sized medium-caking coals at throughputs of about 8 tons per retort per day. The variations in working conditions, yields of products, and properties of the smokeless fuels, are described in terms of the type and size of coal carbonized.

Part 2, which is reproduced here, deals with the use of Woodall-Duckham chamber ovens for the production of smokeless fuel at "medium" carbonizing temperatures. With flue temperatures of 650-850° C. static charges can be carbonized to give satisfactory smokeless fuel for the domestic open fire.

It has been intended in both systems that the solid fuel produced should be a real substitute for household coal, both from the point of view of efficiency and comfort. It is realized that graded gas cokes and oven cokes can be made to burn freely in open grates if these grates are of a special type efficiently built-in and operating with increased draught. It is felt that there will always be a large demand for a smokeless fuel which can be easily ignited with wood and paper, and which will burn freely in the inexpensive type of grate]

(1) *General.*

The carbonization of coal in vertical retorts at relatively low temperatures tends to produce smokeless fuel of open texture which is of low bulk density. Low bulk density may be of advantage from the point of view of ease of ignition and combustibility, but it has several disadvantages which must also be recognized. These are (i.) increased cost of transport, (ii.) increased friability, (iii.) the necessity for more frequent fuelling of the fire, and (iv.) a less degree of suitability for the domestic closed stove. These disadvantages can be largely overcome if the coal is carbonized in static charges. In addition, the possibility of making such charges by blending with strongly caking coals a proportion of weakly-caking coal or coke breeze in order to utilize cheaper materials or waste products is attractive. The only difficulty which arises is the design of a retort for the carbonization of static charges, in which a reasonable thickness of layer of coal can be carbonized at a sufficient rate so that the centre of the charge is fully coked before the outer layer next the retort wall is so far overcoked as to lose its combustibility.

The Fuel Research Brick Retort described earlier in this Paper has shewn that it will carbonize satisfactorily a 7-11 in. layer of coal, without overheating the outer layers, when coking with a retort skin temperature of 600-700° C. The retort is too high, however, for dealing with static charges and for this purpose would have to be reduced to a working height of 12-14 ft.

In order to explore the production of smokeless fuel from a static charge it was arranged to make use of the Station setting of two Woodall-Duckham chamber ovens installed during 1932 for experimental work on the blending of coal. These ovens are designed for the carbonization of coal for gas manufacture and normally operate with the lower combustion chamber temperatures at 1,250-1,350° C.

The use of these ovens for the production of smokeless fuel has been referred to several times by E. W. Smith,[1] who also has carried out experiments at the Ramsgate Gas Works in conjunction with the engineer in charge and with J. Roberts upon the carbonization of blends made according to the latter's patents.[2] The blends were carbonized using the flue temperatures normal for gas manufacture, but the charges were dropped when the temperature in the centre had reached 600° C. The work is described in a paper by J. Ruthven.[3] J. Roberts, in a general paper with G. E. Foxwell, later advocates the use of " medium " flue temperatures[4] and a slower rate of carbonization in order to produce what they describe as " open-grate " coke.

An interesting experiment has been made at the Mines de Bruay by H. Koppers[5] in order to determine the opti-

[1] Gas J., 1924, **167**, 455.
[2] B.P. 187,366 (1921), and 228,686 (1924).
[3] Gas J , 1928, **181**, 397.
[4] J. Inst. Fuel, 1934, **7**, 150.
[5] J. Inst. Fuel, 1933, **7**, 13.

mum width of oven which will give the best conditions for carbonization of coal or blends with medium flue temperatures. Using an experimental oven with one laterally-moving wall he was able to vary his oven width and explore the relation between oven width and time of carbonization. It can be deduced from his curves that an oven such as this chamber oven, having a mean width of 11 inches, would require a carbonizing time of 18 hours when the mean flue temperature was 750° C. A domestic fuel suitable for continental use, *i.e.*, in closed stoves, made under these conditions in 35 cm. Koppers ovens, has been sold since 1931 under the name of Carbolux.

After some preliminary experiments it was decided to conduct the experiments at the Fuel Research Station at combustion chamber temperatures ranging from 850° C. at the bottom to 650° C. at the top of the ovens. Since the ovens widen from 9½ in. at the top to 12½ in. at the bottom, the conditions chosen gave a uniform rate of rise of temperature from top to bottom at the centre of the charge. The preliminary experiments shewed that with these temperature conditions, smokeless fuel having the desired 4-5 per cent. of volatile matter was obtained by carbonization for 20 hours. This period compares with the 18 hours deduced from Koppers' experiments.

It was arranged that a survey should be made of the effect of coal blending upon the nature of the fuel produced and upon the conditions of carbonization and output of the ovens. This programme has little more than started, and it is proposed in this Paper only to give an account of the first series of blends in order to characterize the type of domestic fuel which it is possible to produce in this way.

(2) *Description of Chamber Ovens.*

The setting contains two silica ovens, each capable of taking a charge of 2¼ tons of coal. It is heated by producer gas from a built-in producer, and is fitted with a heat-interchanger for preheating the air for combustion.

The internal dimensions of the ovens are 16 ft. 8 in. high by 8 ft. 0¾ in. long, widening from 9½ in. at the top to 12½ in. at the bottom. The depth of the charge is normally 14 ft. 6 in. The ovens are fitted with three charging doors at the top and one discharge door at the bottom. The coke discharges into a travelling skip, and is thereafter quenched under a quenching tower. Before reaching the tower, the skip passes over a weighbridge, so that the dry weight of the coke is obtained.

The arrangement of the heating flues is that which has usually been fitted with Woodall-Duckham ovens up to the present; thus there are three heating flues for the two ovens, that between the ovens being common to both. Each flue has four horizontal baffles, which distribute the hot gases as they pass upwards. Control is arranged by the use of dampers to cover the ports in the baffles.

In addition to the primary air supply to the producer and secondary air supply to the base of the flues, a tertiary air supply is arranged above the first baffle with the object of reducing the temperature drop in the flues.

Gas off-takes are supplied, both at the top and the bottom of the ovens, with suitable collecting mains and tar tanks.

Arrangements are made to supply steam to the base of the retorts during the later hours of the carbonization period.

The normal temperature gradient for these ovens is from 1,350° C. in the lower, to 950° C. in the upper chamber, and a charge of Durham gas coal is fully carbonized in approximately 12 hours.

For accuracy in test work, arrangements have been made by the Station staff to heat the ovens by cold producer gas, or coal gas, the built-in producer and air preheater being shut down. Under these conditions it was necessary to complete the damper arrangements so that the gas could be made to travel horizontally from one end of the baffle to the opposite end of the next above it. This was not possible in the case of the highest baffle. When using the Fuel Research Station gas burner, and since the preheater chamber cannot be shut off from communication with the combustion flues, it is impossible to increase the pressure in the lower flues above atmospheric. The result of this is that air cannot be excluded from the top flues, and in consequence temperature control at this point is not entirely satisfactory.

After sufficient work had been done at normal high temperatures to enable the staff to become thoroughly acquainted with the manipulation of the plant, during which some success was attained in the use of steam, the programme on carbonization at medium temperatures was commenced. With these relatively low temperatures in the upper flues the temperature in the chimney fell below the dew point of sulphuric acid and a considerable deposit began to accumulate at its base. It was therefore arranged to by-pass the air preheater, which could not be used with the alternative gas supply, and to lead the gas direct from the upper flues into the base of the chimney. This expedient had a satisfactory effect as far as corrosion of the chimney was concerned and might well be necessary in any other plant adapted for this purpose.

(3) *Methods of Test.*

The properties of each coke produced were assessed by (*a*) visual observation, (*b*) amount of breeze produced, (*c*) strength of coke, and (*d*) combustibility in the open fire.

The methods adopted for test are as follows:—

In the preparation of the oven charge of two tons the following method is adopted. The non-caking constituents of the blend are first passed separately through a disintegrator, thus reducing them in size. A sufficient amount of all the constituents is then taken to make a ½ ton blend, and the appropriate number of shovelsful are taken from each and charged together to the disintegrator. During this operation a sample is taken, the weight of blend is checked and the coal taken in skips to the top of the oven. Four skips, each containing 10 cwt. of coal, are required for each charge.

The approximate screen analysis of a prepared blend is as follows:—

	Coal Blend.
On a ¼ in. screen	2
From ¼ ,, to ⅛ in.	12
,, ⅛ ,, ,, 7/64 ,,	22
,, 7/64 ,, ,, 3/32 ,,	20
Through 3/32 in.	44

When the oven is clear from the previous charge a weighed quantity (4 cwt.) of dry sized coke (1¼ to ¾ in.) from a similar blend is placed in the bottom of the oven to take the place of the normal breeze pad; the coal is then charged.

At the end of the carbonizing period of 20 hours the coke is discharged, weighed hot and quenched with water. After draining for 30 minutes the lump coke is forked into skips and the smaller material elevated to a screen, and the breeze (less than ¾ in.) is screened out. During screening, large samples are taken for physical tests and analysis. The object of using dry, sized coke instead of breeze for the bottom pad is to obtain a figure for the breeze produced during carbonization, it being assumed that none of the sized coke added would be crushed sufficiently to pass the breeze screen. Since the important (physical) tests on the coke are conducted on pieces over 2 in. in size, the presence of small, sized coke from a previous charge cannot affect the results.

When the work has progressed a little further it is intended to continue charging optimum blends until it has been shown that the carbonizing time is the minimum possible, *i.e.*, until it is shown that the flue temperatures and the inside temperatures on discharge always reach the same levels at the end of each carbonizing period. It is realized that only thus can true values be found for the variations in time of carbonization which are made possible by the blending of strongly-caking coals with weakly-caking coals and/or breeze.

(4) *Yields from Silkstone and High Delf Coals.*

In order to demonstrate the yields of products obtainable from coal under these conditions the following results are quoted representing two coals of rather different caking power. Since these were straight coals they were not crushed before carbonization, but were charged in the size supplied.

The coals were (*a*) Silkstone (S. Yorkshire) Beans (74

per cent. from 1 in. to ½ in.), and (*b*) High Delf (Forest of Dean) 2 in. to ⅞ in. washed slack (50 per cent. 1 in. to ¼ in.), and the time of carbonization was 20 hours.

The yields were:—

—	Silkstone.	High Delf.
1	2	3
Weight of charge, tons	2·0	2·2
Moisture per cent	4·0	3·5
Ash, per cent.	3·7	7·0
Yields per ton of coal—		
Coke, cwt.	13·92	13·48
Breeze, through ¾ in. per cent.	16·5	15·2
Volatile matter, per cent.	3·7	6·4
Gas, cu.ft.	9,280	4,900
Gas, therms	57·5	33·3
Gas, B.Th.U.	620	679
Spirit, galls.	1·7	..
Tar, galls.	19·1	14·4
Tar, sp.gr.	1·058	1·053

The rate of evolution of the gas from one charge of the Silkstone coal was measured, and the result is shewn in Figure 1, together with the corresponding curve of calorific value.

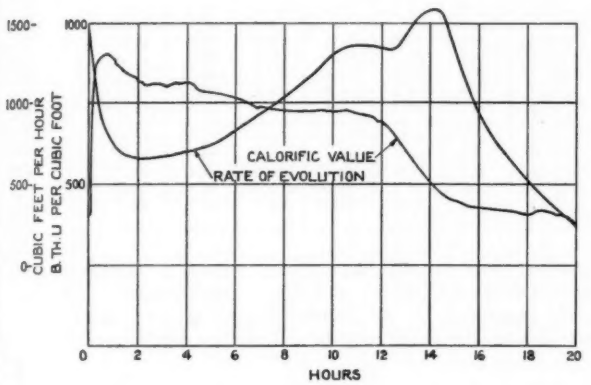


FIGURE 1.—*Typical Curves of Calorific Value and Rate of Evolution of Gas from the Chamber-Oven Charge.*

The cokes of over 2 in. size were examined by shatter test for hardness and by rumbler test for resistance to abrasion (see Appendix I. for method).

Size.	Shatter Test.		Rumbler Test.	
	Silkstone.	High Delf.	Silkstone.	High Delf.
1	2	3	4	5
Over 2 in.	37·7	35·8	9·9	8·0
,, 1½ ,,	56·9	52·3	29·0	19·8
,, 1 ,,	77·2	70·8	58·9	45·5
,, ½ ,,	92·9	89·2	86·8	77·5
Through ½ in.	7·1	10 8	13·2	22·5

These results shew that in both cases the cokes are weak and would break down readily on transport. An average horizontal gas-retort coke would shew at least 80 per cent. over 1½ in. in the shatter test and 60 per cent. in the rumbler test. The amounts through ½ in. would be less than 3 and 11 per cent. respectively.

In the important matter of combustibility in the open grate the cokes were both fairly satisfactory. When examined by the radiation test (Appendix I.) they compared as follows with the low-temperature coke standard.

—	Silkstone.	High Delf.	Standard.
1	2	3	4
Heat for ignition, B.Th.U.	2,580	1,620	1,120
Time for intense fire, mins.	83	60	56
Maximum rate of radiation	1·28	1·10	1·32
Charge consumed, per cent.	65	76	76
Bulk density, lb. per cu.ft.	25·7	24·4	20·6

The cokes were rather more difficult to ignite than low-temperature coke, and did not reach quite so high a rate of radiation. Their greater density is important.

(5) *The Properties of Blend Cokes.*

A considerable number of cokes have been examined in one series, in which one strongly-caking coal has been carbonized with one non-caking coal and/or coke breeze. The ultimate object of the series is to determine the proportions of the blend constituents which will give optimum results as regards (i.) shatter test, (ii.) rumbler test, (iii.) combustibility in the open grate, taking into account also the amount of breeze formed during carbonization. It is not yet possible to indicate more than approximately what these optima are, but the general trend of the changes is apparent, and the properties of the smokeless fuels which it is possible to make in this way are clearly shewn. It will also be realized that the results are given for only two coals and that further work might disclose the particular suitability of certain other combinations.

In exploring this series the strongly-caking coal was first carbonized alone, and in the series of blends the proportions of the other constituents were varied in the direction indicated by the test data collected. It is intended that such data as yields of products, effect of blending upon time of carbonization, &c., will be obtained upon optimum blends only. This stage has not yet been reached.

The results of the strength and combustibility tests are shewn in Tables 1 and 2. In considering the former it is necessary to make certain reservations since neither test used is intended for the evaluation of coke of this type. The distribution of sizes after the shatter test is perhaps best interpreted by considering the percentages of material over 1½ in. and below ½ in. The first gives a measure of hardness or resistance to shock and the second one of friability, which should be in accord with the results of the rumbler test. This latter test measures friability only, *i.e.*, resistance to abrasion, and is probably more important in this case than the shatter index since the handling which a domestic coke receives is more likely to cause breakage by abrasion than by shock or crushing under heavy burden. The important points in the rumbler test are probably the amounts remaining on a 2 in. screen and passing a ½ in. screen. The first shews whether the large pieces still remain and the second whether the surface of the pieces is sufficiently friable to rub down the fines.

Table 1 is arranged in five sections. The first shews the progressive stages in the blending of a strongly-caking coal W with a non-caking coal X. The blend cokes reach an optimum bulk density when the proportions of the coals are 80/20. The proportions of material over 1½ in. in both tests do not show this optimum, but the proportions of fines below ½ in. do, although not markedly. Visual examination of the cokes in this series showed the 80/20 to be the most uniform in quality, and to have the best appearance. It is an interesting finding that this caking coal can take up as much as 40 per cent. of non-caking coal and yet make a satisfactorily strong coke.

The second section of the table shows a similar series in which the non-caking constituent is low-temperature coke breeze. The results form a rather more variable series. The proportions of coke over 1½ in. after both shatter and rumbler tests again increase with dilution, but the proportions of fines begin to increase between 5 and 10 per cent. of breeze, *i.e.*, at a much earlier stage than with the non-caking coal. Visual examination of the series showed the most uniform coke to be the 80/-/20. The blends with lower amounts of breeze produced cokes having soft friable centres. With 30 and 40 per cent. additions of breeze, the coke produced was of large size—several pieces being of full oven width and over 2 ft. in length, but these cokes were noticeably friable.

The third section shews the effect of replacing progressively the 20 parts of non-caking coal in an 80/20 blend by low-temperature coke breeze. The bulk density of the coke decreases slightly owing to the lightening effect of the breeze. In this series the amount of large coke over 1½ in. increases to a maximum and then de-

TABLE 1.—*Physical Tests of Chamber-Oven Cokes.*

Coal W.	Coal X.	Coke Breeze.	Breeze Produced Per Cent.	Bulk Density. Lb./ Cu.Ft.	Shatter Test. On 2 In.	On 1½ In.	On 1 In.	On ½ In.	Through ½ In.	Rumbler Test. On 2 In.	On 1½ In.	On 1 In.	On ½ In.	Through ½ In.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
COAL BLENDS.														
100	..	..	7·4	28·5	53·9	65·4	83·3	95·7	4·3	24·8	41·0	68·2	90·7	9·3
95	5	..	6·1	28·5	62·8	76·2	88·5	96·4	3·6	40·7	54·6	73·3	89·5	10·5
80	20	..	7·6	29·5	60·6	71·5	84·8	94·9	5·1	36·6	51·0	77·3	91·1	8·9
70	30	..	6·3	27·0	69·5	80·6	88·7	94·4	5·6	48·8	65·5	77·9	87·4	12·6
60	40	..	7·7	26·5	72·2	83·0	89·9	93·6	6·4	57·5	72·5	81·8	87·2	12·8
BLENDS OF CAKING COAL AND COKE BREEZE.														
100	..	..	7·4	28·5	53·9	65·4	83·3	95·7	4·3	24·8	41·0	68·2	90·7	9·3
95	..	5	6·2	29·0	61·8	71·3	86·3	95·5	4·5	30·8	47·5	72·3	91·5	8·5
90	..	10	9·7	28·3	50·6	63·0	79·0	93·0	7·0	18·4	34·2	61·5	86·0	14·0
80	..	20	10·2	27·0	53·9	62·8	74·7	88·6	11·4	27·8	38·0	52·6	75·6	24·4
70	..	30	7·8	28·5	84·1	88·0	90·0	92·5	7·5	74·4	78·4	81·0	82·6	17·4
60	..	40	12·9	25·5	73·5	78·3	81·7	86·4	13·6	58·1	61·5	64·1	66·8	33·2
BLENDS OF CAKING AND NON-CAKING COALS AND COKE BREEZE.														
80	20	..	7·6	29·5	60·6	71·5	84·8	94·9	5·1	36·6	51·0	77·3	91·1	8·9
80	15	5	7·4	29·0	69·0	79·5	89·3	95·3	4·7	48·3	61·8	79·5	89·1	10·9
80	10	10	9·6	28·5	73·5	81·8	89·7	94·9	5·1	51·8	62·3	77·1	87·7	12·3
80	5	15	10·0	26·8	65·7	70·2	78·3	89·7	10·3	29·7	39·3	55·3	77·0	23·0
80	..	20	10·2	27·0	53·9	62·8	74·7	88·6	11·4	27·5	38·0	52·6	75·6	24·4
70	30	..	6·3	27·0	69·5	80·6	88·7	94·4	5·6	48·8	65·5	77·9	87·4	12·6
70	25	5	8·8	27·0	74·1	81·9	87·7	92·4	7·6	56·1	67·0	76·9	84·2	15·8
70	20	10	8·5	27·0	74·7	82·0	88·1	93·3	6·7	59·5	72·0	80·1	86·9	13·1
70	10	20	6·9	27·0	78·7	86·1	90·7	94·0	6·0	66·4	74·7	81·0	86·1	13·9
70	..	30	7·8	28·5	84·1	88·0	90·0	92·5	7·5	74·4	78·4	81·0	82·6	17·4
60	40	..	7·7	26·5	72·2	83·0	89·9	93·6	6·4	57·5	72·5	81·8	87·2	12·8
60	30	10	6·8	26·0	76·7	82·0	85·7	90·0	10·0	58·0	67·4	70·8	76·2	23·8
60	20	20	7·9	26·5	79·3	85·0	88·2	91·2	8·8	64·0	73·6	75·0	78·6	21·4
60	10	30	8·1	25·5	84·7	87·9	90·0	91·9	8·1	75·7	79·0	80·5	81·7	18·3
60	..	40	12·9	25·5	73·5	78·3	81·7	86·4	13·6	58·1	61·5	64·1	66·8	33·2

creases again. The maximum is shewn by both tests when 10 parts of the non-caking coal are replaced by 10 parts of breeze. When the amount of breeze is increased above this amount the friability becomes marked, as shewn by the increasing amounts of smalls below ½ in. This is in agreement with the finding in the second section. Visual examination of the cokes shewed that the most uniform coke was obtained by small replacements of non-caking coal by breeze. As the amount of breeze increased the size of the coke increased as above, but friability also increased.

In the fourth and fifth sections the non-caking coal is again replaced by low-temperature coke breeze, starting respectively from 70/30 and 60/40 blends. The findings fall in line with those of the third section; where the proportion of caking coal is 70 the proportion of coke which just begins to cause friability is between 10 and 15, and when the caking coal is 60 the limiting proportion of coke is less than 10 per cent.

Visual examination gave the same conclusions as above with regard to size of coke. With the blends containing 70 and 60 per cent. of caking coal the most uniform cokes were those containing 10 per cent. of breeze. Above this amount friability increased.

Reference has been made in describing the cokes made from these blends to uniformity of structure. Uniformity is particularly important in respect to oven cokes since the rate of carbonization is necessarily slow and the outer layers tend to become overheated before the centre is fully coked. Even, as in these experiments, where the flue temperature is not above 850° C., a distinct difference can be seen in the colour of the outer layers of coke. This difference is most noticeable when caking coals are carbonized. When their caking power is reduced by blending, the difference is less, and, in certain cases, particularly when the blend contains coke, may be scarcely distinguishable.

The grey outer layers of a coke are definitely less combustible than the darker centre, and, if a coke of this type were marketed, its variability would probably lead to dissatisfaction. The difference in combustibility is shewn clearly by the open-fire test.

The difference in bulk density is also noticeable.

The importance of uniformity is such that if this type of coke were to be made on a commercial scale the greatest care would have to be taken in choosing the constituents of blends and their proportions. It has been suggested by K. Bunte[6] that Foxwell's method of measuring the resistance of a layer of sized coal to the passage of a stream of inert gas, while heated at the rate of 1° C. per minute, allows of the assessment in the laboratory of the proportions of blend constituents. This can also be done simply by using the Gray-King assay. Assay cokes for the assessment of blends can be made at the rate of two in 3 hours and the attention required is small.

—	Outer Layer.	Centre.
1	2	3
Gas for ignition, B.Th.U.	2,240	1,950
Time for intense fire, mins.	100	61
Maximum rate of radiation	1·01	1·19
Per cent. fuel consumed	62	61
Bulk density, lb. per cu.ft.	26·4	23·4

The combustibilities of the blends shewn in Table 1 and discussed above were determined by the open-fire radiation test. The results are given in Table 2, which is divided into the same sections as before.

Taking the coal blends first it is seen the introduction of non-caking coal increases combustibility as determined by ease of ignition and the time required to reach an intense fire. The maximum rate of radiation is not greatly affected. When the caking power of the coal is controlled by adding low-temperature coke breeze instead of non-caking coal the effect is proportionately more marked. In this case the maximum rate of radiation is definitely increased. Again, when the non-caking constituent of a blend is progressively substituted by breeze the same increase of combustibility is observed. The effect of the breeze becomes less marked as the caking power of the coal blend decreases, *i.e.*, when the proportion of caking coal is only 60 per cent. its effect is noticeable only in regard to ease of ignition.

The above conclusions are general, and certain individual results would appear to be discrepant. The reasons for this may be the fact that an insufficient number of duplicate tests have as yet been done, but may

[6] Gas u. Wasserfach, 1933, **76**, 685.

TABLE 2.—*Combustibility of Chamber-Oven Coke.*

Coal W.	Coal X.	Coke Breeze.	Heat for Ignition. B.Th.U.	Time for Intense Fire. Mins.	Max. Rate of Radiation. Units/ Min.	Charge Consumed. Per Cent.
1	2	3	4	5	6	7
1. COAL BLENDS.						
100	..	..	2,240	79	1·12	60·0
95	5	..	2,630	72	1·08	57·0
80	20	..	2,020	74	1·30	68·0
70	30	..	1,800	69	1·20	64·0
60	40	..	1,800	61	1·19	68·0
2. BLENDS OF CAKING COAL AND COKE BREEZE.						
100	..	..	2,240	79	1·12	60·0
95	..	5	2,180	86	1·14	58·0
90	..	10	2,240	88	1·12	..
80	..	20	1,510	66	1·25	63·0
70	..	30	1,590	62	1·20	65·0
60	..	40	1,400	63	1·18	65·0
3. BLENDS OF CAKING AND NON-CAKING COAL AND COKE BREEZE.						
80	20	..	2,020	74	1·30	68·0
80	15	5	1,900	73	1·10	63·0
80	10	10	1,800	90	1·16	64·0
80	5	15	2,130	74	1·08	64·0
80	..	20	1,510	66	1·25	63·0
4. 70	30	..	1,800	69	1·20	64·0
70	25	5	1,720	59	1·32	68·0
70	20	10	1,790	63	1·29	65·0
70	10	20	1,820	66	1·23	68·0
70	..	30	1,590	62	1·20	65·0
5. 60	40	..	1,800	61	1·19	68·0
60	30	10	1,540	70	1·14	66·0
60	20	20	1,570	61	1·19	66·0
60	10	30	1,290	60	1·21	65·0
60	..	40	1,400	63	1·18	65·0
Standard of comparison .			1,120	56	1·32	76·0

also be due to the recognized difficulties in sampling large coke.

(6) *Comparison of Brick-Retort Coke and Chamber-Oven Coke.*

It has been shewn in Part 1 that the brick retort will give, under optimum conditions with a suitable coal, a constant throughput of 8 tons per retort per day. Similarly it has been shewn that the throughput of the chamber oven, working at "medium" temperatures with a suitable blend, will be of the order of 2·5 tons per day. The difference is due in part to the effect of oven width, and in part to the greater rate of input of heat which is possible when the coal is in motion and can act as a cooling medium for the retort walls. As regards the effect of width, the greater width of the chamber oven necessitates a lower flue temperature in order that the outer layers of the charge shall not be overheated while time is being allowed for the transfer of heat to the centre of the charge. As regards the effect of a moving charge of coal it is apparent that the temperature difference can be relatively great near the point of entry of the coal, and consequently the input of heat can be large and a greater amount of coal can be carbonized.

It is possible that further experience in the working of chamber ovens under these conditions may decrease this apparent disadvantage, but in the meantime it is of interest to compare the types of smokeless fuel produced. When this is done the advantages would seem to lie with that produced in the chamber oven. The comparison is best made between the retort fuel made from a very suitable coal and the oven fuel made from an optimum blend.

In the first place the bulk densities compare as 20·0 lb. for retort fuel and 29·0 lb. for oven fuel per cu.ft. of 1¼ to 1 in. pieces. The greater density of the oven fuel means lower transport charges, less handling during use, and greater suitability for closed stoves as a substitute for anthracite.

So far as strength is concerned the oven fuel has also a distinct advantage; the shatter and rumbler test results compare as follows:—

—	Shatter Test.			Rumbler Test.		
	On 2 In.	On 1½ In.	Through ½ In.	On 2 In.	On 1½ In.	Through ½ In.
1	2	3	4	5	6	7
Retort fuel	62	77	8	31	54	20
Oven fuel .	69	80	5	43	62	11

Not only is the shatter index of the oven cokes distinctly the higher, but the amount of fines passing a half-inch screen is also appreciably less. The same findings are possible in the rumbler tests, so that the oven fuel can be said to be both stronger and less susceptible to attrition than the retort fuel.

The combustibilities of the two types of fuel compare as follows, when examined by the open fire test described in Appendix I.

—	Retort Fuel.	Oven Fuel.
1	2	3
Heat for ignition, B.Th.U. . . .	1 120	1,900
Time for intense fire, mins. . . .	35	73
Maximum rate of radiation, units. .	1·42	1·10
Per cent. consumed	76	63

The retort fuel is therefore more readily ignited, burns up more quickly, and reaches a higher rate of radiation than the oven fuel. The latter is, however, sufficiently free-burning for general use, and its slower rate of combustion may even be, in certain circumstances, a definite advantage. This conclusion suggests that the advantages of chamber-oven coke could be realized in association with higher throughput if the oven could be constructed with a less width. Calculation from Koppers' curves[1] indicates that a reduction of mean oven width to 9½ in. would increase the throughput of coal by about 50 per cent.

APPENDIX 1.

PHYSICAL TESTS OF COKE.

(1) COMBUSTIBILITY TEST.

An empirical test has been evolved at the Fuel Research Station for the assessment of the suitability of cokes for use in the domestic open grate. The test has been used over a period of years for the comparisons of different types of coke, and, when used in conjunction with general observations on the comfort of the fires produced, has formed a valuable and rapid means for the evaluation of domestic fuels.

In this test a standard volume, 0·39 cu.ft., of the fuel to be examined, of 1 to 1¼ in. size, is placed in a domestic open grate and ignited by means of a measured quantity of coal gas burned below the grate. The gas supply is stopped when it is estimated by the operator that the fuel is properly ignited. For this part of the test, experience is necessary.

Observations are taken of the thermal radiation received upon a radiometer placed at a distance of three feet from the centre of the fire and arranged as shown in Figure 2. The charge of fuel is allowed to burn to extinction and the amount of unburned material weighed. From the known ash content of the fuel the amount of residual carbonaceous matter can be calculated.

The results are tabulated to give (*a*) the heat required for ignition, (*b*) the time required to reach a condition of

[1] J. Inst. Fuel, 1933, 7, 13.

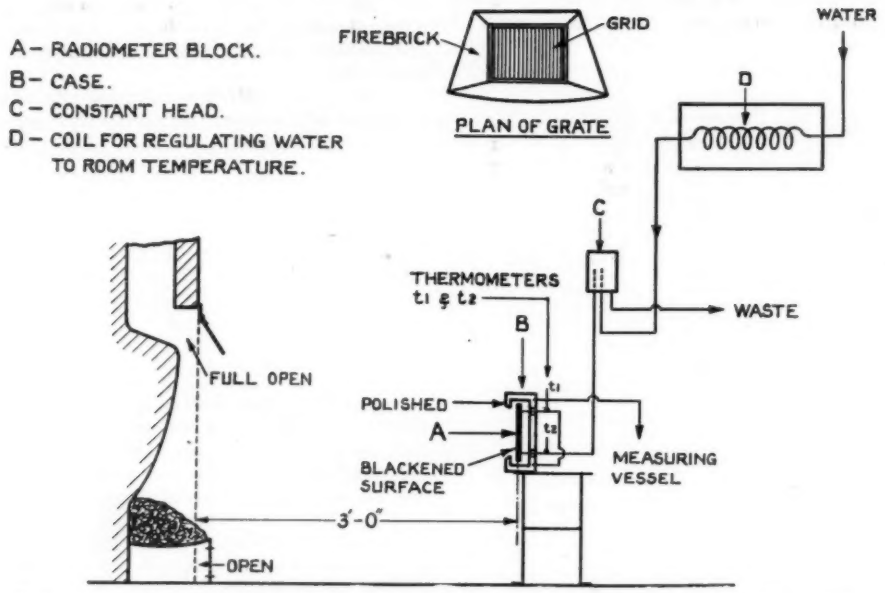


FIGURE 2.—*Diagram of Method for the Determination of the Combustibility of Coke.*

" intense " fire, (*c*) the highest rate of radiation reached, and (*d*) the percentage of fuel consumed. In addition, a graph shewing the rate of radiation on a time basis is drawn. Comparisons are made with a " standard " fuel consisting of low-temperature coke of 1 to 1¼ in. size.

The definition of an " intense " fire is one which is glowing at a sufficiently high temperature for normal comfort. This condition has been made to correspond with unit rate of radiation per minute. This is, of course, an arbitrary definition, and in the case of standard fuel in a well-type grate, unit rate, as received by the radiometer is 1·05 B.Th.U. per minute on a surface of 36 sq. in.

The method is definitely empirical, and the results are of value only in a comparative sense, and if the conditions laid down are strictly adhered to. The position for the radiometer was chosen as that receiving radiation from the fire at the highest rate in the vertical plane 3 ft. from the fire. In Figure 2, for a well-type grate, the centre of the radiometer surface receives the radiation at an angle of 15° to the horizontal.

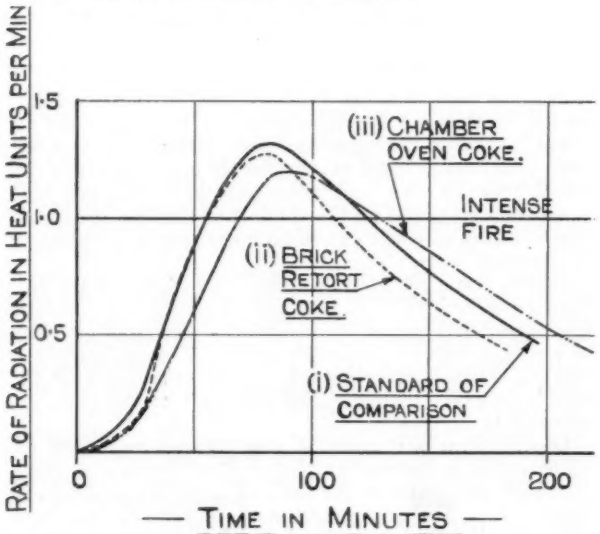


FIGURE 3.—*Combustibility Curves.*

Figure 3 shews typical curves for

(i.) the standard of comparison, a low-temperature coke made in Fuel Research cast-iron retorts at 625° C.;

(ii.) a low-temperature coke made in Fuel Research brick retorts at 700° C.;

(iii.) a chamber-oven medium-temperature coke made from a blend at a flue temperature of 650-850° C.

The numerical data from these tests were as follows:—

Fuel	(i.)	(ii.)	(iii.)
Heat for ignition, B.Th.U.	1,120	1,070	1,900
Time for intense fire, mins	56	53	73
Maximum rate of radiation, units	1·32	1·26	1·10
Per cent. consumed	76	71	63
Bulk density, lb. per cu ft.	20·6	17·7	29·0

(2) SHATTER TEST.

Apparatus.

The apparatus used in the Shatter Test consists essentially of a box 18 in. wide, 28 in. long, and 15 in. deep, the bottom of which consists of two doors hinged lengthwise and latched so that they will swing open freely and allow the contents of the box to fall unimpeded. The box is suspended in a framework above a rigid cast-iron or steel plate 38 in. wide, 48 in. long, and ½ in. thick, in such a way that it can be raised for the test or lowered to a convenient height for filling. The inside edge of the box at its highest position is 6 ft. above the plate. Boards about 8 in. high are placed around the plate so that coke is not lost.

Description of Test.

Fifty pounds of the coke to be tested, over 2 in. in size, is placed in the box, the coke levelled, the box raised, and the coke dropped on to the metal plate. The box is then lowered and all the coke shovelled into it indiscriminately, but taking care to avoid breakage. When the coke has thus been dropped four times in all, it is screened by hand in such a way that any piece which can be passed through the screen in any position is counted as undersize. The weights of coke of each grade are determined to the nearest ounce.

Screens.

For determining the breakage of the coke sample B.S. Coarse Mesh Test sieves with the following openings should be used: 2 in., 1½ in., 1 in., and ½ in.

Statement of Results.

At least three tests should be made and the results recorded as percentages remaining on the screens. If the average deviation of the individual results from their mean exceeds 2·5 and 1·5 units with the 2 in. and 1½ in.

screens respectively, a further series of at least two tests should be made and the average of all results taken.

(3) Rumbler Test.

Apparatus.

The apparatus for this test consists of a metal drum 40 in. long and 3 ft. in diameter, having a tightly fitting door for the charging and discharging of coke. The inner surface of the drum is fitted with three radial fins, 8 in. high along the length of the drum, and set 120° apart. The drum is mounted horizontally in bearings so that it can be rotated at a speed of 25 r.p.m.

Description of Test.

Fifty pounds of the coke to be tested, over 2 in. in size, is placed in the drum, the door closed, and the drum rotated for 50 revolutions at a speed of 25 r.p.m. The rotation is stopped when the door is at the lowest position, the door is opened and the coke discharged and all carefully collected and screened by hand in a manner similar to that described for the Shatter Test. At least three tests are made.

The screens used are the same as those used for the Shatter Test, and the results are stated in a similar manner.

(4) Caking Power by the Gray-King Assay.

The standard apparatus of the Gray-King assay[8] is followed except that the apparatus for the collection of products need not be used. The retort tubes takes a charge of 20 gm. of coal (all < 72 B.S.I. screen), and the rate of heating of the furnace is from 300 to 600° C. in 1 hour, *i.e.*, 5° C. per minute. If a coal gives a hard coherent coke of the same volume as the original coal it is regarded as of standard caking power. If the coal is of less caking power it may give all grades of coke from one of standard size but friable surface to one which is entirely non-coherent. If it is of greater caking power the coal is blended with electrode carbon (< 72 B.S.I. sieve) until the blend gives a standard coke. The amount of carbon in 20 gm. of the blend is an index of caking power. The highest indices are shewn by the Durham caking coals; these vary from 8 to 10.

[8] Fuel Research Tech. Paper 21, 1929.

APPENDIX 2.

DESCRIPTION OF COALS USED.

The analyses and Gray-King assays of the coals are shewn in Table 3.

Table 3.—*Analyses and Gray-King Assays of Coals Used.*

Coal	W	X
Proximate analysis, air dried—		
Moisture	1·3	10·3
Volatile matter less moisture	32·1	35·0
"Fixed carbon"	61·2	47·5
Ash	5·4	7·2
Ultimate analysis, dry coal—		
Ash	5·5	8·0
Carbon	81·5	76·9
Hydrogen	5·2	4·9
Nitrogen	1·7	1·9
Sulphur	1·8	2·6
Difference	4·3	5·7
Gray-King assay at 600° C.—		
Yields per ton of dry coal—		
Coke, cwt.	15·1	13·8
Tar, galls.	27·4	30·5
Liquor, galls.	7 8	15·9
Gas, cu.ft.	4,230	3,860
Gas, sp. gr. (air = 1)	0·612	0·775

Coal W.—Run-of-mine Durham Gas Coal as mined at the Thornley Colliery by the Weardale Steel, Coal and Coke Company, Ltd., Spennymoor, Durham. The coal is a mixture of many seams.

Coal X.—Double-screened nuts as mined at the Pooley Hall Colliery, Warwickshire, of the Pooley Hall Colliery Company, Ltd.

Primitiva Holdings, Ltd.

ORDINARY GENERAL MEETING

The Fifth Ordinary General Meeting of Primitiva Holdings, Ltd., was held at Winchester House, Old Broad Street, E.C. 2, on Tuesday, May 22—Mr. P. Ashley Cooper (Chairman of Directors) presiding.

The Manager and Secretary (Mr. Mark Denne) read the notice convening the meeting, together with the Auditors' report on the balance-sheet for the year ended April 30, 1934.

THE CHAIRMAN'S ADDRESS.

The Chairman, having moved the adoption of the report and accounts, in the course of his address to the shareholders, said that some shareholders had been disappointed at the dividend they had recommended. This disappointment was a perfectly natural one coming as it did at a time when dividends from many sources had been reduced, but they also believed that it arose, perhaps, from a not altogether complete understanding of the position.

Some of them might have felt because the Gas Company paid a dividend of 5% in Roca Bonds that they would have paid the same dividend. Those who had followed the course of Argentine finance knew that these Bonds were not the result of last year's profits, but the accumulation of pesos over a period which were funded in the form of Bonds and handed to the Gas Company. Even so, a reference to the accounts of the Gas Company showed that the dividend was only made possible by drawing heavily on the carry-forward and on the reserves. They decided that it was in the shareholders' interest to transfer these Bonds to the Holdings Company, and the method adopted was the only one by which the Directors could at the same time recommend an ordinary dividend.

He would remind them that some years ago they stated that they believed that transferring to the Holdings Company would be to their ultimate benefit. To-day they still held that view, and they would not overlook the fact that the profit was available in the accounts. He assured them that never for a moment did they contemplate distributing the whole of these accumulated funds. The problem which the Directors faced was not one of a dividend, or a bigger dividend. It was whether, in the circumstances, they were justified in paying a dividend at all. They were anxious to pay a dividend, but felt they should be reasonably sure of being able to do so again next year. Moreover, it was their first duty to preserve their property, and that demanded a policy of great caution.

The Primitiva Gas Company.

The Chairman then gave an outline of the activities of the subsidiary Companies during the year 1933. Taking the Primitiva Gas Company first, that Company's accounts showed that they spent some £47,000 on capital account. This included various small additions to mains and plant, but by far the largest items were new services and new meters. In spite of the strict control both in capital and revenue expenditure which they had been exercising for some years now, new services and meters were items which they must always be prepared to finance.

The Holdings Company had lent a large sum of money to the Gas Company, and during the year under review the Directors of this Company called for security. Thus £105,000 of the 1911 debentures appeared on the Gas Company's balance-sheet as having been issued as collateral.

On the liabilities side of the Gas Company's balance-sheet the principal change was the reduction in the contingencies reserve from £165,000 by £115,000 to £50,000.

Revenue in Buenos Aires had increased by £4,000, which they felt was satisfactory in the circumstances, but loss in exchange was £92,636—an amount equal to 3% on the Gas Company's shares. The balance of profit and loss account at £186,241 compared with £166,643 for the year 1932. After providing for an allocation of £75,000 to depreciation and renewals they were left with £111,241. Having regard to the difficulties of operation during the year and the heavy loss on exchange, this could not be regarded as unsatisfactory.

So far as the operations of the Gas Company were concerned, the staff had been fully engaged, apart from routine and construction, in improving organization, tightening up control, and

studying the future. Even with restricted development there was no lack of outlets for well-directed energy and enterprise.

In looking back over a year not conspicuous for major works or spectacular progress, they could say that the house was in order, control in each Department had further improved, and the interest of their managers and staff keener than ever in developing and perfecting the machinery of control. As a result of this closer control, the rational economies to which he referred last year had continued.

With regard to prospects, their organization was good, and they had a great potential future; but exchange was still the dominating factor. So far as the present year was concerned, the official rate of exchange was lower than the average for 1933, and the free rate had now fallen to about 53% of par. This depreciation of exchange would certainly hit them hard. Even so, he was hopeful that, if conditions got no worse, they might be able to pay at least the same dividend next year. But their first duty must be to preserve their property, so that it would remain theirs and continue to make profits.

Mr. FRANK H. JONES, M.Inst.C.E., seconded the resolution for the adoption of the report and accounts, which was unanimously carried; after which the retiring Director (the Rt. Hon. Viscount St. Davids) and Auditors were re-appointed, which concluded the business of the meeting.

North of England Gas Managers' Association (Auxiliary Section)

Half-Yearly Meeting at Sunderland

The 28th half-yearly meeting of the Auxiliary Section of the North of England Gas Managers' Association was held at the Gas Offices, Sunderland, on Saturday, May 26, when a large attendance listened to an address on the Hendon Gas-Works by the Chairman, Mr. F. P. Fall, Chief Draughtsman to the Sunderland Gas Company.

The address was preceded by a visit to the Hendon Gas-Works, where the plant was inspected by the members, who were conducted around the works by their Chairman, together with Mr. A. H. Bagshaw (Works Manager), Mr. W. O. Kirkwood (Chief Chemist), and Mr. J. Richardson (Technical Assistant).

Before giving his address, Mr. Fall said that he wished to express his pleasure at the presence that afternoon of Mr. C. Dru Drury, Director and Engineer of the Sunderland Gas Company.

Mr. DRURY gave a hearty welcome to the members to Sunderland on behalf of the Chairman and Directors of the Sunderland Gas Company. They took, of course, a certain amount of coke oven gas. The situation of the works at Hendon was a pleasant one and practically on the cliffs of the sea. There was ample evidence that flowers and shrubs did not suffer by close proximity to gas-works.

Sunderland was first supplied with gas in 1824 by a small Company on the south side of the Wear. Later, a small Company was started on the north side of the river at Monkwearmouth, and each Company for a time supplied their respective sides of the river. Then competition had arisen. One Company had secured permission to carry mains across the bridge and had started to supply the opposite side. Two sets of mains were thus laid in the same district and no one knew precisely whose gas they were taking. That sort of thing had continued until amalgamation took place in 1854, and three years later the present Company emerged as the Sunderland Gas Company.

CHAIRMAN'S ADDRESS.

Mr. Fall then delivered his Address (see below, on this page).

Mr. F. NICHOLLS (Gateshead) moved a vote of thanks to the Chairman for his Address, and Mr. J. W. PALLISTER (Middlesbrough) seconded.

The vote of thanks was carried with acclamation.

Mr. FALL briefly responded, and then proceeded with the presentation of the Certificate to Mr. J. B. Henderson, Newcastle and Gateshead Gas Company, Wallsend, the Past-Chairman, to commemorate his year of office. It was, he said, the first presentation of its kind in the Auxiliary Section, and while it was some time since it had been decided to mark the completion of the Chairman's year of office in this way, various circumstances had caused delay; but he had now much pleasure in asking Mr. Henderson to accept the certificate together with the good wishes of the members.

Mr. HENDERSON, replying, said that he would take the opportunity of reminding the younger members that the submission of a paper was the first step towards the Chair. Their Secretary (Mr. L. M. Weldon) was sometimes at a loss to find suitable subjects and papers for their meetings, and he would always welcome any suggestions in this respect from the younger members. It gave him much pleasure to accept the Chairman's Certificate.

Mr. G. W. NEIL (West Hartlepool) moved a vote of thanks to the Chairman and Directors of the Sunderland Gas Company, which Mr. D. YULE (South Shields) seconded, and it was warmly carried.

Tea was later taken at the invitation of the Directors.

Chairman's Address

By F. P. FALL, of the Sunderland Gas Company.

The honour you accorded me at our last meeting in electing me to the chair of the Auxiliary Section of the North of England Gas Managers' Association is deeply appreciated, and I can assure you my earnest endeavour will be to continue the good work of my predecessors in office. In glancing through past records, I find that since the inception of the Section in 1918 I am the fourth official of the Sunderland Gas Company to receive your confidence, and although on three previous occasions the Section has been to Sunderland, this is the first visit to the chief of the two manufacturing stations of the Company. I do not propose to give you a detailed survey of our works at Hendon, but to make the subject of my address as interesting as possible I will describe—

(1) Some of the most interesting features of the works.

(2) Some extensive repairs to gasholders at Hendon.

In pre-war years the coke breeze which we automatically accumulated from our coke shipments and land sales was inclined to be looked upon as a drug on the market rather than as a revenue producer, and the method adopted for keeping the stock of it down to a reasonable tonnage was to utilize it for steam raising purposes in boilers fitted with special forced-draught furnaces.

The natural development of the works to meet the increased demand for the supply of gas necessitated a corresponding increase in our boiler plant with the ultimate result that, instead of having a surplus of coke breeze, it became necessary to obtain supplies from outside sources, and from 1924 to 1928 inclusive we purchased a total of 4,400 tons to meet the requirements of our two works with the expectation that future purchases would be in increasing quantities.

WASTE HEAT BOILER.

As the cost of the purchased breeze delivered to the boilers had reached the figure of £800 per annum, it was natural that alternative methods of steam raising should be considered. One method which at that time was receiving strong support was to raise steam with the available surplus heat from the retort benches by the aid of high velocity fire-tube boilers. These boilers were giving such excellent results where they had been installed that a strong case had been made out for their general adoption, ample proof being forthcoming that steam could be raised

at a much less cost per ton than could be done when working boilers fired with breeze.

In 1929 we installed in the main retort house at Hendon a Spencer-Bonecourt fire-tube boiler to work in conjunction with one of the two benches of retorts, each bench consisting of 10 beds of eight 21 in. by 16 in. by 19 ft. retorts. This particular house, which has a central chimney to serve the two benches, is somewhat narrow compared with modern design, and, as the headroom from ground level to underside of stage floor does not exceed 10 ft., a certain amount of ingenuity had to be exercised in designing the most suitable lay-out for such a cramped site. The boiler 6 ft. 6 in. diameter by 15 ft. 6 in. between tube plates has a heating surface of 2,000 sq. ft. and is suitable for a working steam pressure of 120 lbs. per sq. in. It is provided with Sugden superheater units to raise the temperature of the steam 100° F. and induced draught equipment consisting of "Sirocco" fan directly coupled to vertical high-speed engine to draw the gases through the tubes and discharge them to atmosphere through an independent steel chimney 58 ft. high. The central chimney damper for controlling the draught on the bench is, of course, closed when the boiler is at work. Automatic feed water regulation is also provided and the usual safety valve arrangements. The tubes are regularly cleared of flue dust, a certain number being cleaned each day so that the full complement receives attention once a week. The total weekly cost of this operation amounts to a few shillings only.

The working of the boiler is completely automatic, but as a precautionary measure superficial inspection is carried out by the retort house foreman at intervals of not more than two hours.

Although since its installation the boiler has only worked for about four years the amount saved in the cost of the labour and fuel which otherwise would have been required for breeze-fired boilers has more than redeemed the total capital outlay. The output of a boiler of this type is determined by many factors, such as amount of coke to producers, control of setting, condition of bench brickwork, &c., and it will be realized that difficulty would be experienced in comparing our results with those obtained from similar installations. Suffice it to say that the evaporation figures per lb. of fuel consumed in the producers put forward by the makers in their tender have been exceeded in actual practice.

Water Softening.

It will be readily understood that for a boiler of fire-tube design a particularly soft feed water is necessary if the formation of scale on the external surface of the tubes with the consequent reduction in efficiency is to be avoided. After consideration and inspection of various systems of water softening it was decided to install a "Neckar" plant. In this system of water softening the permanent hardness in the crude water is entirely removed in a reaction tank by the addition of soda ash, while the bulk of the temporary hardness down to about 1° is also removed in the same tank by working at a temperature of approximately 200° F. A continuous sludge return from the boiler to the softener provides a means for obtaining any desired concentration of salts in the boiler water. It is, in addition, of some assistance in reducing the hardness; the amount of boiling water returned to the softener in this way does not exceed 5% of the total volume of water fed to the boiler. The total hardness of Sunderland water averages 28°, and no difficulty is experienced in reducing it to the working figure of 1°. The effective performance of the softener is reflected in the clean and "free from scale" condition of the boiler.

Resulting from the introduction of the waste-heat boiler, a battery of three 7-ft. Lancashire boilers which had been in regular use since 1903 was thrown out of commission. These boilers had reached the stage when the cost of repairs and maintenance was becoming excessive, in addition to which they were only suitable for a working pressure of 80 lbs. per sq. in., neither were they fitted with superheaters, whereas the major portion of our steam raising plant was designed for a working pressure of 120 lbs. per sq. in. with the steam superheated 100° F.

Central Power House.

With the removal of this obsolete boiler plant, an opportunity was provided of centralizing our power plant, which, owing to the growth of our works, had become scattered and somewhat cramped, while, in addition, so many separate units did not tend to efficient supervision.

The scheme which is at present being carried out consists of reconstructing the boiler house and adjoining exhauster house by pulling down the chimney and the division wall between the two houses, replacing the old purlined and slated roof with a new boarded and slated roof complete with two rows of patent roof glazing and ventilation system, plastering the walls and tiling the floor. A 5-ton overhead traveller running on a gantry supported on steel stanchions has been installed for handling the various power units. The plant when finally assembled will consist of two sets of steam-driven gas exhausters each of 120,000 c.ft. per hour capacity, two similar sets each of 60,000 c.ft. capacity, one 40-KW. electric generator direct-coupled to horizontal gas engine, two similar generating plants each with an output of 20 KW., and one small steam-driven generator of 7-KW. capacity; direct current only is generated. The remaining plant consists of one small air compressor for providing the air supply to the purifiers and a gas compressor for atomizing purposes. Provision has been made in the lay-out of the plant for larger units if and when required, and also possible gas boosting plant. The interior lighting will be effected with the latest type of gas burner operated by switch control.

Utilization of Exhaust Steam.

Arising out of this centralization of power, a scheme was developed for the collection of the exhaust steam for the heating of softened boiler feed water by indirect contact. The various exhaust pipes are led underground into a common collecting main of sufficient capacity to carry the available steam without creating a back pressure. This main is connected to two heat-exchangers which are a relic of the benzole plant erected at Hendon for war requirements but now dismantled. Each exchanger, 3 ft. 4 in. diameter by 11 ft. 9 in. long, is fitted with 143 tubes $1\frac{3}{4}$ in. o.d. by 10 ft. long. The steam passes through the vessels in parallel, entering at the top and venting to atmosphere from the bottom, the cold water passing contra flow through the tubes and thence to the boilers. The system has not been long in operation, so that no reliable data can yet be given. We have no difficulty, however, with the exhaust steam available from half the steam driven plant previously mentioned, in raising the temperature of the feed water required for two 30 ft. by 8 ft. 6 in. Lancashire boilers from 50° F. to 205° F.

Ash Separation.

Although the method of recovering the combustible matter from pan ashes at Hendon was described fully in a paper which I had the pleasure of reading before this Section in 1928 [see "JOURNAL" for June 6, 1928 (Vol. 182), p. 666], it will not, perhaps, be out of place if I again refer to the subject.

The plant, so far as I am aware, is the only type which separates the coke from the clinker in a dry state, the operation being effected by means of electro-magnetic attraction on the principle that while the iron compounds in the clinker are susceptible to magnetic influence, the coke is not. The pan ashes are fed into a receiving hopper and then elevated to a rotary screen, where the fine ashes and oversize lumps are removed, the remainder of the material passing forward to the revolving magnetic drums where the actual separation takes place. The combustible matter is immediately thrown clear, while the clinker with its iron element adheres to the surface of the drum until it has passed beyond the influence of the magnetic field which extends for about half the circumference of the drum. After nine years' working the plant is still capable of giving 95% separation efficiency, while the renewal of wearing parts is not a costly item.

Gasholder Repairs.

Within the last few years the question of the proper inspection and maintenance of gasholders has received considerable attention from the Factory Department of the Home Office and the Council of the Institution of Gas Engineers. A Sub-Committee appointed by the Institution issued its first report on the subject in 1932 and therein emphasized the necessity for the adequate inspection of holders and the keeping of a systematic record of such procedure. The recommendations contained in the report did not necessitate alteration to any great extent in the policy already in operation at Sunderland, as regular and thorough inspection of the holders was recognized works practice.

The storage capacity at Hendon consists of four column-guided holders working in brick and puddle tanks as shown below:

No.	Capacity, C.Ft.	No. of Lifts.	Diameter of Tank.	Date of Erection.
1	500,000	2	120 ft.	1861
2	500,000	2	120 ft.	1871
3	1,000,000	2	153 ft.	1884
4	1,500,000	3	153 ft.	1894

So far as our records show, no major repairs were carried out to any of the holders prior to 1920. In that year we

installed water gas plant having a throughput of 2,000,000 c.ft. B.W.G. per 24 hours, and it was decided that the two-lift holder erected in 1861 should be utilized as a relief holder for the plant. As, however, the holder was floating about 6 in. out of level, the time was considered opportune for making a thorough examination both internally and externally and carrying out any repairs and adjustments which were found to be necessary. Before this work could be commenced, however, the contents of the tank amounting to about 1,600,000 gallons of water had to be removed, an operation which, with the means at our disposal, required ten days to complete. In the meantime a few of the crown sheets were removed for venting the interior. Four days were allowed to elapse after the water had been removed before it was considered a workable atmosphere inside the holder.

The first job was the removal of the naphthalene slurry lying on the puddled clay bottom. This slurry varied in depth from 12 in. at the centre pillar to 24 in. at the rest blocks. Only very short stretches could be worked by relays of men owing to the foul atmosphere caused through the churning up of the slurry. The inspection of the interior showed that the majority of the rest blocks, 24 in all, had broken off at the junction with the brick wall of the tank and that some of the internal cup rollers were missing. Making good the rest blocks in concrete was carried through with some difficulty as although the outer lift was slung from the tank coping with lifting screws, the weight of the inner lift remained on the blocks. Our programme was to renew the blocks in pairs raising the lift for this purpose with hydraulic jacks placed on adjacent blocks. The load, however, proved too much for the clay bed on which they were set; for, instead of the jacks raising the lift, the pressure simply forced the blocks further into the tank bottom. Eventually, by spreading the load over a much greater area we managed to raise the lift the necessary amount for placing the concrete in position.

The plumbing of the column guides proved them to be as much as 3 in. out of the vertical. These guides consisted of cast iron tee bars held in position by cast brackets projecting from the columns, many of the brackets being fractured. It was decided to replace the tee guides with mild steel channels, inserting suitable packings between channel and bracket to bring the guide paths plumb. New guide wheels with flat rim were provided to replace the grooved wheels.

An examination of the crown and side sheeting suggested that, although a considerable number of small patches had been fixed in the crown, the material which was of puddled wrought iron throughout was generally in good condition and did not warrant extensive renewals being undertaken. On the completion of repairs and other adjustments, the holder was put into commission for the storage of water gas.

Incidentally the Hendon works are built on a barrier between two collieries, and although actually on solid ground, the draw from the adjacent workings is sufficient to account for the tilt of the holder columns.

In 1924 this holder required further attention. Small leakages had been appearing at frequent intervals at a number of the seams in the crown, and the conclusion arrived at was that the water gas was having a deleterious effect on the sheeting. Considering the age of the holder (63 years) it was decided again to open out for a more critical examination of the sheeting, and this further inspection revealed a state of fairly heavy corrosion at the seams of the crown sheets. In addition, the hanging row of the inner lift was badly pitted. The marked difference in the appearance and condition of the sheets in the short space of four years was, to say the least, surprising, but there is no doubt that the carburetted water gas was responsible for removing the hard rust and loosening the scale with the resultant showing up of defects not otherwise noticeable. The affected areas were far too extensive to patch up satisfactorily, and the work of renewing the crown and hanging row was put in hand.

With the removal of the top sheeting, the crown framing, which was of very light construction, was found to have a decided radial twist amounting to 15 in. from the straight; in addition, twenty of the cast-iron struts connecting the rafters to the main ties were broken. With the aid of pulley blocks most of the twist was taken out of the framing, after which additional concentric bracings were fixed. The broken struts were either repaired or replaced with mild steel angles. The hanging row and crown, with the exception of the two outer rows of sheets—which, on account of their extra thickness, were still in good condition—were replaced with sheets of mild steel. Opportunity was also taken to fix sealing manlids in the crown immediately over the inlet and outlet stand pipes. Although it was unnecessary to renew the outer rows, the plates to which the top guide carriages were attached were reduced in thickness through corrosion, so the carriages were removed to allow of stiffening plates being fixed. After the completion of repairs and the usual adjustments for level had been made, the holder was again brought into use, and up to the present no further trouble has been experienced.

Mention has been made of the fact that the draw from colliery workings was sufficient to cause the columns of the holder to tilt.

In 1929 various small happenings to the largest of our holders, such as bending of lattice bars and finding of broken rivets, indicated that ground movement had set up abnormal stresses in the guide framing, which was of Cutler's patent design. I might here mention that a serious accident to the tank of this holder, and its cause, was the main subject of a paper which my Chief, Mr. Drury, read before the Senior Association in 1925 [see "JOURNAL" for May 6, 1925 (Vol. 170), p. 368].

The contractors for the holder were approached and arrangements made for them to make a detailed examination of the guide framing and also to plumb the 26 columns. A complete record which was prepared of their findings indicated that most of the columns were cut of plumb and that many of the diagonal lattice girders were twisted. In addition, the framework, instead of being circular, was inclined to elliptical, there being a definite major and minor axis. To correct this fault the flanges of ten of the 26 channel guides were burnt off with oxy-acetylene burners and new channels fixed to the correct dimensions with the aid of cast-iron packs varying in thickness from $4\frac{1}{8}$ in. to $\frac{5}{8}$ in. and placed at 3 ft. 3 in. centres. Several of the guide carriage cheeks had to be shortened and correspondingly smaller diameter wheels provided to meet the new conditions, while in other cases larger diameter wheels were necessary. After the repairs had been completed, a final set of plumbings showed that no column guide was more than $\frac{1}{4}$ in. out of the vertical.

Perhaps the most interesting of all our repair jobs was the one carried out in 1932 to the 500,000 c.ft. holder erected in 1871. It had been reported that the level of the water seal in the cup could not be maintained without assistance from the works water supply, suggesting that the cup was corroded through—a fact which later was confirmed. The cup was only 16 in. in depth and as the holder threw a pressure of $6\frac{3}{4}$ in. and in addition was floating $3\frac{1}{2}$ in. out of level, it will be seen that the seal was operating with a very small margin of safety. It was also reported that when the inner lift was floating uncupped in heavy winds the up and down motion at water line amounted to as much as 6 in., indicating that the internal cup rollers were certainly not doing the work for which they were intended. Previous experience had shown us these disturbing features could not be taken lightly and in view of the fact that the holder, which again was of puddled wrought iron, had been in commission for a period of 63 years, it was considered advisable to lay it off with the expectation of extensive repairs being necessary.

The possibility of carrying out the work without having to empty the tank received favourable consideration, and with this end in view a supply of steam was provided for purging the gas space in the holder. After 48 hours' steaming some of the crown sheets were removed to allow of free ventilation. This caused a further delay of three days before tests of the atmosphere indicated that it would be safe to enter the crown. Two rafts were constructed for giving easy access to all parts of the interior, after which the sheeting was replaced and an air lock fixed. Appliances were provided to meet the regulations laid down for the safety of life, these appliances consisting of life belts and oxygen breathing apparatus which were placed on the rafts; in addition we also carried a supply of white mice. The holder was raised by means of a small portable air compressor and the examination proceeded with.

The inspection showed that most of the cup rollers were missing, the cup which was of circular section was holed at various points and the crown framing twisted radially. External examination of the cup also showed extensive pittings. Discussion with welding experts as to the advisability of making good the cup by a "building-up" process was of a negative character, and the alternative method of providing a new cup was decided upon. This decision, of course, necessitated the removal of the water and slurry, a procedure which was carried out on similar lines to that adopted in 1920. Measurements were taken for the construction of the new cup which was to be formed of mild steel channel and plate rivetted together instead of repeating the original design of circular section pressed plate. Sections of about 15 ft. 6 in. in length were prepared and holed at the contractors' works ready for erection, and so accurately had the measurements been taken that no closer was required, neither had drifting of holes to be resorted to. Previous to the fixing of the new cup, mild steel flats varying in thickness from 3 in. to $\frac{3}{4}$ in. were placed on the rest blocks to give a level bed for the cup to

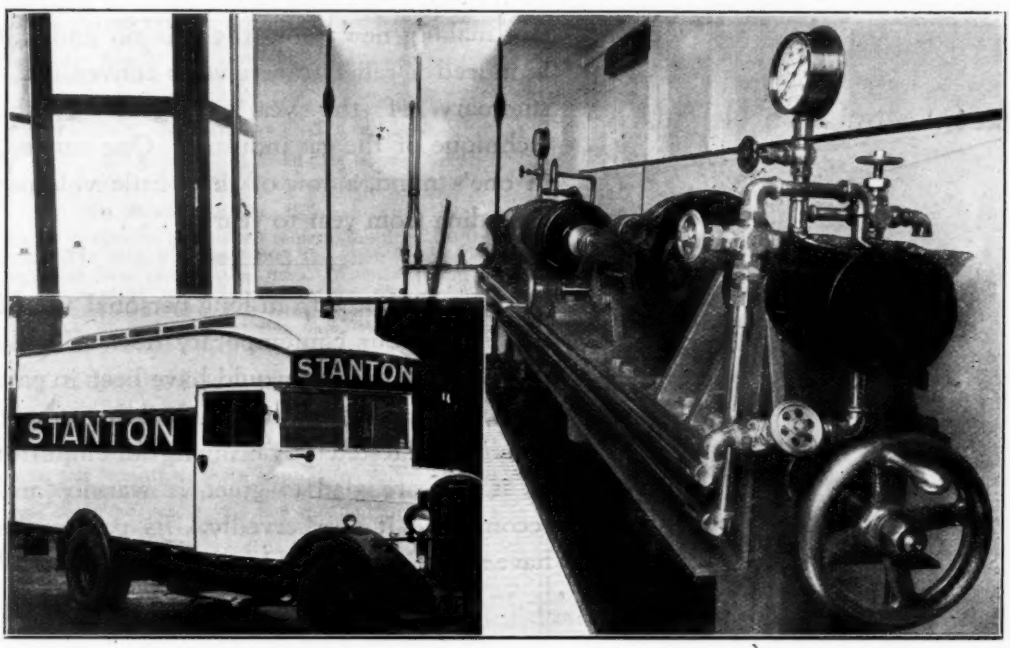
rest on. It was considered advisable to stiffen the crown framing, which had a minimum amount of concentric bracing, and for this purpose diagonal cross ties with screw couplings were attached to the rafters. Sealing manlids were also fixed in the crown over the stand pipes, and new internal carriages and rollers were supplied, together with new pins for the top carriages, which were bushed to suit.

During the period of repairs it was considered desirable to have tests carried out on samples of material cut from the old cup and some of the crown sheets. It was found that although the tensile strength was still up to British Standard Specification requirements the material had lost some of its ductility. These results were not unexpected as they confirmed generally tests on similar classes of material carried out in other quarters—in fact, in another case within my knowledge the elongation of the material was only 3% in 8 in. as against the usual minimum of 16%—a state of affairs which rather suggests that, although such material may be quite sound in appearance, there is always a possibility of fracture if abnormal stresses are set up.

This, of course, raises the ever present question of wrought iron *versus* mild steel in gasholder construction. It must, however, be borne in mind that the material referred to was rolled over sixty years ago, and from my own observations I very much doubt whether mild steel working under similar conditions would even approach a similar age; in fact, quite a number of gasholders constructed in mild steel have been re-sheeted after working less than thirty years.

In conclusion, I should like to express thanks to my Chief, Mr. Chas. Dru Drury, for the generous way he acceded to my request for permission to address you to-day, and for the members of the Auxiliary Section to visit the Hendon Works.

A Van and its Contents



In order to provide a practical demonstration of the Stanton flexible pipe-joints for the benefit of engineers who are unable to visit Stanton, a special van has been equipped for this purpose by the Stanton Ironworks Company, Ltd., near Nottingham. Built on a Thornycroft chassis, the van contains examples of both the Stanton-Wilson self-adjusting joint for use with Stanton Delavaud spun-iron pipes and the Stanton-Cornelius flexible joint for Stanton centrifugally-made concrete pipes. The pipes and joints contained in the van are not models, but are specimens of the actual products as supplied by the Company. The van also contains the necessary equipment for subjecting the joints to water or air pressure in order to demonstrate their property of remaining leaktight under deflection or vibration. Explanations of the technical details are clarified by sectional models of each joint.

Accompanied by members of the Stanton Company's technical staff, this van is now touring the country, and it is hoped to call on many engineers who have not hitherto had an opportunity of inspecting these joints at first hand. It is anticipated that the van and its contents will prove of special interest to engineers who have experienced trouble with rigid joints on account of the heavy traffic vibration which is so prevalent to-day.

The Stanton-Wilson self-adjusting joint has now been adopted with complete success by about 400 undertakings. Not only is it claimed to offer a permanent safeguard against the effects of traffic vibration, but also to enable cast-iron mains to adjust themselves to the movements of the subsoil. The joints can be made rapidly by unskilled labour, and they also enable easy curves to be taken with ordinary straight pipes.

The Demonstration Van also contains Stanton "Hard-Stud" cast-iron road-sections, of the type used in the new Mersey Tunnel. Apart from their primary use as a heavy-traffic road-surface, these sections are particularly suitable for the paving of works yards, loading-floors, &c.

The advantages of a practical demonstration of these products over a printed or verbal description need scarcely be emphasized, and the welcome which the van has received on the initial stages of its tour suggests that this new form of Stanton service will be greatly appreciated by engineers and surveyors.

Trade Notes.

B.E.N. Patents, Ltd.

Owing to expansion of business, B.E.N. Patents, Ltd., of Gorst Road, Park Royal, N.W. 10, have appointed Mr. A. G. Roper as Assistant Sales and Service Manager at their head office at Park Royal. Previously, Mr. Roper was in charge of their showrooms at 92, Tottenham Court Road, and his place there has been filled by Mr. A. Keall, who has experience in all B.E.N. equipment.

Technical Signpost for 1933

"... In these days of voluminous writings ('of making new books there is no end'), it is indeed a relief to receive so convenient a summary of the year's progress in the technique of the gas industry. One can see in one's mind, a row of these little volumes extending from year to year. ...."

"... We know from long personal use of the files of our contemporary how valuable this new publication would have been in past years, and having carefully studied the present volume and tested it by bringing our enquiries to it, we are glad to greet it warmly and recommend it unreservedly. Its paragraphs have been skilfully and lucidly prepared. ..."

(Extracts from Reviews)

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Register of Patents

Water-Cooled Condensers.—No. 399,746.

HUMPHREYS & GLASGOW, LTD., and MORGAN, G. H., both of Westminster.

No. 12,794; May 2, 1933.

Objects of this invention are to reduce the cost of gas condensers and the ground space required for their installation, and to enable the water tubes to be cleaned internally without having to shut down the condensers.

A condenser according to the invention comprises a vessel formed internally with a substantially volute spiral, or like gas passage, the top and bottom of which are constituted by tube plates, above and below which are water spaces corresponding generally to the gas passage and connected by substantially vertical water tubes extending through the gas passage. Each of the water spaces is divided by partitions so disposed that water admitted to one end compartment of, say, the upper water space will flow successively down through some tubes and up through others in zigzag fashion and in a generally counter-current direction in relation to the gas. The upper water space may be uncovered so that the upper ends of the tubes are always accessible and the tubes can be cleaned through this space.

A central pipe with lateral aperture may serve to lead gas from above or below to the inner end of the gas passage, the gas outlet therefrom being at the periphery of the vessel; or this arrangement may be reversed. The water may be admitted to one compartment of the outer convolution of the upper water space, and after passing down and up through the tubes be discharged through a lateral outlet from the last compartment of the inner convolution; where the gas flow is reversed the water flow is also reversed. The water may be admitted to a compartment of the lower water space.

Firing Retort Settings.—No. 399,948.

CARPENTER, C. C., ANDREWS, A. H., and the SOUTH METROPOLITAN GAS COMPANY, of 709, Old Kent Road, S.E. 15.

No. 20,335; July 18, 1932.

In settings for horizontal or inclined retorts, the flues are frequently arranged in such a manner that the main combustion flue is branched to form continuation flues. When, in order to increase the temperature in these continuation flues, supplementary air and gas, or air or gas, is to be admitted, it is convenient to arrange the admission at the place where the main flue branches, so as to avoid a port or set of ports for each continuation flue.

It is difficult, however, to arrange the admission at the fork of the main flue in such a manner that the fluid does not enter the main flue in a direction more or less counter to the current of gas about to distribute itself into the continuation flues, whereby disturbing eddies are produced.

According to this invention, there is provided at the fork of the main flue a burner having passages for the fluid so directed that a stream of air or gas, or air and gas, is delivered into the current of gas entering each continuation flue in the same direction as that in which the current is flowing.

Where the main combustion flue is between the vertical rows of retorts and is continued by flues in opposite directions over the topmost retorts, there is provided in the roof of the setting at a place directly above the main flue a burner the orifices of which are on opposite sides of the body of the burner, so that the streams of fluid issuing from the orifices enter each into a continuation flue and travel in the same direction as that in which the existing stream is travelling in that flue.

Radiators.—No. 400,186.

R. & A. MAIN, LTD., of Falkirk, and WORTLEY, G. W., of Grosvenor Gardens, S.W. 1.

No. 11,064; April 18, 1932.

This invention relates to gas radiators for fixing on walls and for use in inflammable atmospheres. The gas burners are grouped together towards the centre of the bottom of the casing, and means are provided for deflecting the hot gases on to the walls of the casing. A lighting aperture is provided in a wall of the casing near the burners.

The means for deflecting the gases comprises a cowl disposed above the burners and having lateral openings therein directed towards the walls of the casing.

The casing is provided with a removable bottom plate on which the cowl and gas burners are mounted, and in which air inlet holes are formed. The removable bottom plate is provided with an upwardly directed marginal flange arranged to extend up into the casing and which forms a tray for collecting any condensed moisture.

The air inlet openings and the outlet openings are covered with a number of thicknesses of wire gauze which are spaced apart, and the lighting aperture is closed by a removable plate.

To obviate the convection currents produced by the radiator depositing dirt on the wall above the radiator, a deflecting plate is attached to the back of the radiator so as to contact with the wall of the room in which the radiator is to be located and so as to leave a gap between the deflecting plate and the back of the radiator. The deflecting plate is curved over the top wall of the radiator. This arrangement deflects the air currents away from the wall.

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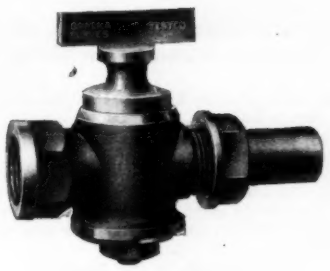

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GAS MARKETS & MANUFACTURES

Stock Market Report.

[For Stock and Share List, see later page.]

As was anticipated, the last few days of the three-week Account saw a considerable falling off in activity in most sections, and, with a small amount of liquidation in evidence, led to the marking down of prices. Investors, however, will doubtless be turning their attention to the several new issues which are to be made this week, and these, coinciding with the opening of a new Account, should give a fillip to business generally. The most important of the new issues is that by the Canadian Government of £10,000,000 in 3¼% stock, redeemable 1950-55, at a price of 96½%.

Despite the dullness displayed in many other sections, the Gas Market was again well supported, and as will be seen in the Stock and Share List several quotations advanced in value. The highest rises occurred in Tottenham 5½% preference and Bournemouth 7% max., both with gains of 3 to 128½ and 167½ respectively, while Bournemouth 4% debenture hardened 2½ to 107½. On the local Exchanges the only alteration was that of Sheffield ordinary, which followed up the previous week's gain of 2 points with a further 1 to 138, which is the top price for any stock in the List paying a 6% dividend. As with the Bristol Company, this is doubtless partly attributable to a large local popularity, though, having regard to the security offered and the Company's progressive policy the price is fully justified. The yield works out at £4 7s.%.

There are several parcels of popular stocks on offer at the time of writing on which 6% has been distributed for some years past and which yield a few shillings higher than this—viz., £1,000 Cardiff and £200 Hornsey, both at 132, yielding £4 10s. 10d.%, and £1,844 Liverpool, at 133, yielding £4 10s. 2d.%. Another stock which merits attention at the current price is Croydon 5% maximum at 107½, the return in this case working out at £4 13s. 5d.%.

Current Sales of Gas Products.

The London Market for Tar Products.

LONDON, *May* 28.

There is but little change to report in the prices of tar products, which are as follows:

Pitch, 57s. 6d. per ton f.o.b.
Creosote, 3½d. to 3¾d. per gallon.
Refined tar, 4d. to 4¼d. per gallon in bulk at makers' works.

Pure toluole, 2s. 6d. to 2s. 7d.; pure benzole, 1s. 9d. to 1s. 10d.; 95/160 solvent naphtha, 1s. 8d. to 1s. 9d.; and 90/160 pyridine, 6s. 6d. to 7s. per gallon naked at makers' works.

Tar Products in the Provinces.

May 28.

The average prices of gas-works products during the week were: Gas-works tar, 24s. to 29s. Pitch—East Coast, 55s. to 57s. 6d. f.o.b. West Coast—Manchester Liverpool, Clyde, 55s. to 57s. 6d.* Toluole, naked, North, 2s. 0½d. to 2s. 2½d. Coal-tar crude naphtha, in bulk, North, 6½d. to 6¾d. Solvent naphtha, naked, North, 1s. 5d. to 1s. 6d. Heavy naphtha, North, 10d. to 11d. Creosote, *ex* works, in bulk, North, liquid and salty, 3d. to 3½d.; low gravity, 3½d. to 3⅝d.; Scotland, 2⅝d. to 3¼d. Heavy oils, in bulk, North, 3⅜d. to 4¼d. Carbolic acid, 60's, 2s. to 2s. 1½d. Naphthalene, £10 to £11. Salts, 55s. to 75s., bags included. Anthracene, "A" quality, 2½d. to 3d. per minimum 40%, purely nominal; "B" quality, unsalable.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port it will be necessary to deduct the loading costs and the tolls whatever they may be.

Tar Products in Scotland.

GLASGOW, *May* 26.

While no great price fluctuations have taken place during the week, fresh business is coming in quite satisfactorily.

Crude gas-works tar.—The actual value is 35s. to 37s. per ton *ex* works.

Pitch.—Export price is purely nominal at round 45s. to 47s. 6d. per ton f.o.b. Glasgow. Home trade is dull with value at 42s. 6d. to 45s. per ton *ex* works.

Refined tar to specification.—Distillers are now busy fulfilling contracts. To-day's value is 3¾d. per gallon *ex* works naked.

Creosote Oil.—Prompt supplies are scarce in this area and quotations are therefore firm. B.E.S.A. specification oil is 4d. to 4¼d. per gallon; low gravity, 4¼d. to 4¾d. per gallon; and neutral oil, 4½d. to 4¾d. per gallon—all f.o.r. in bulk.

Cresylic Acid.—Production is well looked after and prices are steady. Pale, 97/99%, is 1s. 2½d. to 1s. 3½d. per gallon; dark, 97/99%, 1s. to 1s. 1d. per gallon; and pale, 99/100%, 1s. 4d. to 1s. 5d. per gallon—all f.o.r. in buyers' packages.

Crude naphtha is commanding 4¾d. to 5¼d. per gallon, according to quality and quantity.

Solvent naphtha remains dull with 90/160 grade offered at 1s. 4d. to 1s. 4½d. per gallon, and 90/190 grade at 8d. to 8¼d. per gallon.

Motor benzole is scarce, with value at 1s. 6d. to 1s. 7d. per gallon.

Pyridines.—90/160 grade is 5s. to 5s. 3d. per gallon, and 90/140 grade 5s. 6d. to 6s. per gallon.

Benzole Prices.

These are considered to be the market prices for benzole at the present time:

	s.	d.		s.	d.	
Crude benzole	0	9	to	0	9¼	per gallon at works
Motor ,,	1	4	,,	1	4½	,, ,, ,,
90% ,,	1	4½	,,	1	5	,, ,, ,,
Pure ,,	1	7½	,,	1	8	,, ,, ,,

Contracts Advertised To-Day.

Coal.

Neath Corporation. [p. 620.]
Spenborough Gas Department. [p. 620.]

Increased Sales at Guernsey.

The Directors' report for the twelve months ended March 31 last shows that a further new record in sales was reached by the Guernsey Gas Light Company, there being an increase of 9,851,000 c.ft. in the quantity of gas sold, the total amounting to 194,265,700 c.ft. as compared with 184,412,900 c.ft. in 1932-33. The number of consumers also increased by 253, making the total at the end of the year 6,930. Mains have been extended in various parishes a total distance of 5,506 yards, making the mileage at the end of the year 65. New showrooms were opened in Smith Street, St. Peter's Port, in September last, and that they have proved a complete success is shown by the fact that the sales of gas fittings, including hire purchase of stoves, increased from £1,536 to £2,078. The balance at the credit of the profit and loss account after paying interest on debenture bonds and making other allocations, amounts to £13,261, and the Directors have fixed the dividend at 17s. 6d. per share which will absorb £6,562, gross, leaving a balance of £5,598 to be carried forward.

Record Results at Belfast.

Sales of gas exceeded last year's figures by over 103 million c.ft., and established a new record. Record figures have also been reached by the maximum day's output and maximum week's output—all the more remarkable in view of an abnormally dry summer. The gross profit on the manufacture and sale of gas and residuals was £138,055, an increase of £1,773. Dividends and interest on reserve funds investments, sinking fund interests, rents from property, and interest on suspense, bring the total to £153,316. The net profit is £73,693. From the net profit has been set aside £22,399 for redemption of stock and mortgages, leaving £51,294. To this is added the balance brought forward from last year of £29,793, making a total of £81,086. Allocations have been made to the reserve and other funds, interest and sinking fund on new City Hall, and £11,000 in relief of rates, totalling in all £63,120, leaving a balance to be carried forward to credit of appropriation account of £17,967. Sales of gas amounted to 4,242,060,000 c.ft. The gas made, amounting to 4,334,671,000, shows an increase of 1·1%, while unaccounted-for gas has been reduced to the low figure of 2·137%. Of the gas made 28·86% was water gas, and 71·14% coal gas. The prepayment meter rental was greater by £17,505, while sales through ordinary meters fell by £8,961. In the manufacture of water gas the consumption of gas oil was reduced to 2,151,102 gallons, as compared with 2,250,269 gallons last year, on account of its higher cost following the imposition of the duty of 1d. per gallon. Even with the reduced consumption the expenditure under this head has increased by £12,865, the tax itself having added a burden of almost £9,000 to manufacturing costs. The quantity of coal used for coal gas manufacture was 175,093 tons, an increase of 4,906 tons, but the coal bill was reduced by £5,142. Coke sales had been maintained at a very satisfactory level, and had contributed £2,159 more to revenue than last year. The chemical department had contributed to the revenue account £55,994, an increase of £1,782, in spite of the fact that prices of products had been reduced as a result of severe competition. Tar products had again provided an increase in revenue amounting to £1,055. The quantity of gas supplied for street lighting amounted to over 351 million c.ft.

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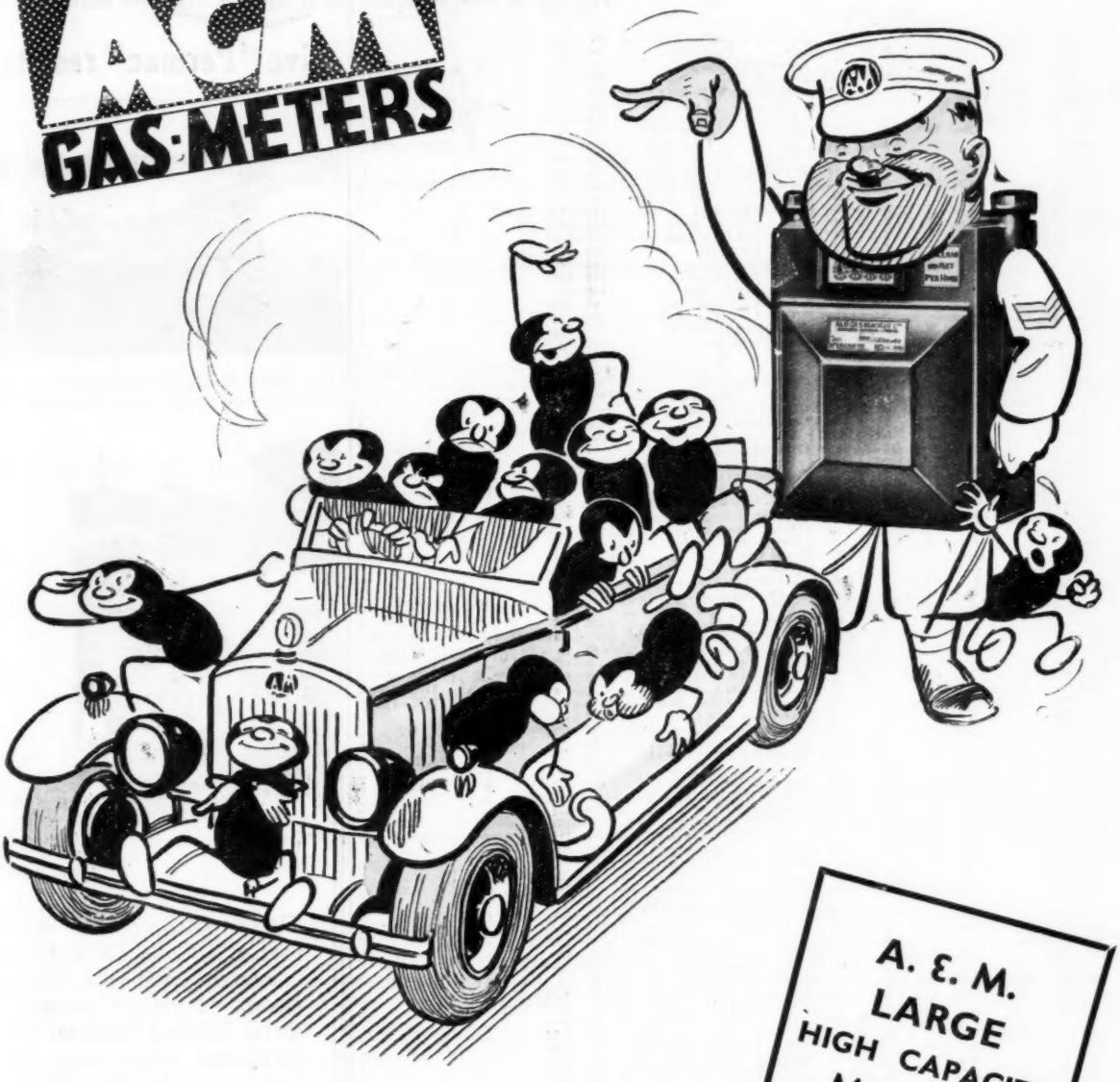

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1,551,868	Stk.	Apl. 9	7	7	Alliance & Dublin Ord. ...	128–138	...	...
374,000	"	Jan. 8	4	4	Do. 4 p.c. Deb. ...	90–100	...	...
557,655	"	Mar. 5	7	7	Barnet Ord. 7 p.c.	167–172	+2	170½–171½
300,000	1	May 7	1/4⅔	1/9⅓	Bombay, Ltd.	26/6–28/6	...	27/
178,480	Stk.	Feb. 19	9½	9½	Bournemouth sliding scale	203–208	...	...
550,050	"	"	7	7	Do. 7 p.c. max. ...	165–170	+3	168½–170
439,160	"	"	6	6	Do. 6 p.c. Pref. ...	142–147	...	...
50,000	"	Dec. 18	3	3	Do. 3 p.c. Deb. ...	79–84	...	...
262,025	"	"	4	4	Do. 4 p.c. Deb. ...	105–110	+2½	108¼–109¼
335,000	"	"	5	5	Do. 5 p.c. Deb. ...	121–126	...	...
357,900	"	Mar. 5	7½	7½	Brighton, &c., 6 p.c. Con. ...	161–166	...	...
540,000	"	"	6¾	6¾	Do. 5 p.c. Con. ...	151–156	...	154½–155
195,500	"	"	6	6	Do. 6 p.c. B. Pref.	140–145	...	...
1,487,500	"	Mar. 5	5	5	Bristol 5 p.c. max.	116–117*a*	...	...
120,420	"	Dec. 18	4	4	Do. 1st 4 p.c. Deb. ...	104–106*	...	...
217,870	"	"	4	4	Do. 2nd 4 p.c. Deb. ...	104–106*	...	...
328,790	"	"	5	5	Do. 5 p.c. Deb.	123–125*a*	...	...
885,000	"	Apl. 9	7	8	British Ord.	153–158	...	155½–157
100,000	"	Dec. 18	7	7	Do. 7 p.c. Pref.	153–158	...	...
350,000	"	"	5½	5½	Do. 5½ p.c. Pref.	106–111	...	...
120,000	"	"	4	4	Do. 4 p.c. Red. Deb. ...	97–102	...	...
450,000	"	"	5	5	Do. 5 p.c. Red. Deb. ...	109–114	...	...
160,000	"	Jan. 8	5	5	Cambridge 5 p.c. Deb. ...	115–120	...	...
100,000	10	22 May '33	6	4	Cape Town, Ltd.	1½–3½	...	2½
100,000	10	Nov. 6	4½	4½	Do. 4½ p.c. Pref. ...	5–7	...	6
150,000	Stk.	Dec. 18	4½	4½	Do. 4½ p.c. Deb. ...	95–100	...	96½–97½
626,860	"	Feb. 19	6	6	Cardiff Con. Ord.	128–133	...	130
237,860	"	Jan. 8	5	5	Do. 5 p.c. Red. Deb.	103–108	...	...
157,150	"	Feb 19	5	6½	Chester 5 p.c. Ord.	112½–123½*b*	...	...
98,936	1	May 7	2/-	2/-	Colombo, Ltd. Ord.	1 7/8–1 13/16	...	...
24,500	1	"	1/4½	1/4½	Do. 7 p.c. Pref. ...	18/6–20/6	...	...
609,204	1	Mar. 19	/11'48	/11'48	Colonial Gas Assn. Ltd. Ord.	1–1⅛	...	20/7½–20/10½
296,053	1	"	1/3'80	1/3'80	Do. 8 p.c. Pref.	23/6–25/6	...	24/10½–25/4½
1,775,095	Stk.	Feb. 19	5	6½	Commercial Ord.	120–125	...	140
475,000	"	Dec. 18	3	3	Do. 3 p.c. Deb. ...	77–82	...	...
285,344	"	Mar. 5	5	5	Do. 5 p.c. Deb. ...	120–125	...	...
807,560	"	Feb. 19	7	7	Croydon sliding scale ...	154–159	+1	156–158
569,590	"	"	5	5	Do. max. div.	105–110	...	...
620,345	"	Jan. 8	5	5	Do. 5 p.c. Deb. ...	121–126	...	...
543,270	"	Mar. 5	7	10	Derby Con.	175–180*e*	...	...
55,000	"	Jan. 8	4	4	Do. 4 p.c. Deb.	98–100*	...	...
209,000	"	Feb. 19	5	5	East Hull Ord. 5 p.c. ...	106–111	...	...
181,625	"	Mar. 5	6	6	East Surrey Ord. 5 p.c. ...	126–131	...	...
175,609	"	Dec. 18	5	5	Do. 5 p.c. Deb. ...	118–123	...	...
1,002,180	"	Apl. 9	15	†7	European, Ltd.	122–127	...	123½–125
19,342,763	"	Feb. 19	5⅔	5⅔	Gas Light & Coke 4 p.c. Ord.	26/10½ 27/4½*f*	+ /1½	27/–27/4½
2,600,000	"	"	3⅓	3⅓	Do. 3⅓ p.c. max. ...	87–90	...	87–88½
4,477,106	"	"	4	4	Do. 4 p.c. Con. Pref. ...	103–106	...	104½–105½
6,102,497	"	Dec. 18	3	3	Do. 3 p.c. Con. Deb. ...	85–88	...	85½–87
8,642,770	"	"	5	5	Do. 5 p.c. Red. Deb. ...	116–119	...	118½ 118⅔
3,500,000	"	"	4½	4½	Do. 4½ p.c. Red. Deb. ...	114–117	...	115½–116½
270,466	"	Mar. 5	6	6	Harrogate New Cons. ...	125–130	...	...
82,500	"	Mar. 5	7	7	Hastings & St. L. 5 p.c. Conv.	147–152	...	150
258,740	"	"	5½	5½	Do. 3½ p.c. Conv	115–120	...	...
140,000	1	Apl. 23	1/7½	1/7½	Hongkong & China, Ltd. ...	1¼–1⅝	...	...
218,200	Stk.	Mar. 5	6	6	Hornsey Con. 3½ p.c. ...	128–133	...	130
5,600,000	"	Nov. 6	14	10	Imperial Continental Cap.	214–219	...	211½–217
228,180	"	Feb 5	3½	3½	Do. 3½ p.c. Red. Deb.	89–94	...	...
235,342	"	Mar. 5	8½	8½	Lea Bridge 5 p.c. Ord. ...	169–174	...	...
2,167,410	"	Mar. 5	6	6	Liverpool 5 p.c. Ord. ...	130–132*b*	...	...
245,500	"	Dec. 18	5	5	Do 5 p.c. Red. Pref. ...	101–111*	...	...
308,083	"	July 17	4	4	Do. 4 p.c. Deb. ...	101¼–108¼*b*	...	...
165,786	"	Feb. 19	8	10	Maidstone 5 p.c. Cap. ...	180–190	...	...
56,176	"	Jan. 8	3	3	Do. 3 p.c. Deb. ...	72–77	...	...
75,000	5	Dec. 4	†10	†10	Malta & Mediterranean ... Metropolitan (of Melbourne)	9–11	...	...
393,000	—	Apl. 3	5½	5½	5½ p.c. Red. Deb.	98–103	+2	102
231,978	Stk.	Feb. 19	5	5	M. S. Utility "C." Cons. ...	113–118	...	115½–115½
818,657	"	"	4	4	Do. 4 p.c. Cons. Pref.	95–100	...	...
380,075	"	Jan. 8	4	4	Do. 4 p.c. Deb. ...	100–105	...	...
148,955	"	"	5	†5	Do. 5 p.c. Deb. ...	117–122	...	...
675,000	"	21 May '31	16	6	Montevideo, Ltd.	63–68	+½	63½–64½
2,061,315	"	Mar. 5	5	8½	Newcastle & Gateshead Con.	25/–25/6*d*	...	...
682,856	"	"	4	4	Do. 4 p.c. Pref. ...	99–101*d*	...	...
776,706	"	Jan. 8	3½	3½	Do. 3½ p.c. Deb. ...	92–93*d*	...	...
277,285	"	May 7	5	5	Do. 5 p.c. Deb. '43 ...	105–107*d*	...	...
274,000	"	Feb. 19	5	5	Newport (Mon.) 5 p.c. max.	106–109*a*	...	...
204,940	"	Mar. 19	7½	7½	North Middlesex 6 p.c. Con.	155–160	...	...
394,160	"	Feb. 5	5	5	Northampton 5 p.c. max. ...	99–104	...	...
300,000	"	May 7	†9	†7	Oriental, Ltd.	155–160	...	...
316,617	"	Dec. 18	8	8	Plym'th & Stonehouse 5 p.c.	167–172	+2	168–171
504,416	"	Feb 19	8	8	Portsm'th Con. Stk. 4 p.c. Std	168–173	...	...
241,446	"	"	5	5	Do. 5 p.c. max. ...	105–110	...	...
114,000	"	Feb 19	5	5	Preston 5 p.c. Pref.	103–108	...	...
686,312	"	Jan. 22	4	4	Primitiva 4 p.c. Rd. Db. 1911	87–92	...	...
389,813	"	Dec. 18	4	4	Do. 4 p.c. Cons. Deb.	88–93	...	...
150,000	10	Mar. 19	6	6	San Paulo 6 p.c. Pref. ...	7 8	...	...
1,736,968	Stk.	Mar. 19	6	6	Sheffield Cons.	137–139*c*	+1	...
95,000	"	Jan. 8	4	4	Do. 4 p.c. Deb.	96–100*	...	...
133,201	"	Feb 19	5	5	Shrewsbury 5 p.c. Ord. ...	135–140	...	138
90,000	10	June 12	15	14	South African	2½–4½	...	...
6,709,895	Stk.	Feb. 19	5	7	South Met. Ord.	131–134	+1	131½–134
1,135,812	"	"	6	6	Do. 6 p.c. Irred. Pf.	140–145	...	143–145
850,000	"	"	4	4	Do. 4 p.c. Irred. Pf.	103–107	+1	104½ 105¼
1,895,445	"	Jan. 8	3	3	Do. 3 p.c. Deb. ...	84–87	...	86⅔
1,000,000	"	Jan. 22	5	5	Do. 5 p.c. Red. Deb.	114–117	...	115½
209,820	"	Mar. 5	8½	8½	South Shields Con.	166–167*d*	...	...
1,543,795	"	Feb. 19	6	6	South Suburban Ord. 5 p.c.	130–133	...	130½–131
512,825	"	"	5	5	Do. 5 p.c. Pref.	118–123	+1	119–122
300,000	"	"	—	4	Do. 4 p.c. Pref.	103–108	...	104
868,837	"	Dec. 18	5	5	Do. 5 p.c. Deb.	121–126	...	...
100,000	"	"	4	4	Do. 4 p.c. Deb.	103–108	...	...
647,740	"	Mar. 5	5	5	Southampt'n Ord. 5 p.c. max.	109–114	...	...
121,275	"	Dec. 18	4	4	Do. 4 p.c. Deb.	100–105	...	...
350,000	"	Mar. 5	5½	5½	Swansea 5½ p.c. Red. Pref.	106–111	...	...
200,000	"	Dec. 18	6½	6½	Do. 6½ p.c. Red. Deb.	103–108	...	...
1,076,490	"	Mar 5	6⅔	6⅔	Tottenham and District Ord.	148–153	...	151½–153
409,835	"	"	5½	5½	Do. 5½ p.c. Pref. ...	126–131	+3	...
62,235	"	"	5	5	Do. 5 p.c. Pref. ...	112–117	...	...
199,005	"	Dec. 18	4	4	Do. 4 p.c. Deb. ...	97–102	...	...
85,701	"	Apl. 9	6	6	Tuscan, Ltd. 6 p.c. Red. Db.	90–100	...	...
349,110	"	Mar. 5	7	7	Uxbridge, &c., 5 p.c. ...	150–155	...	...
88,330	"	"	5	5	Do. 5 p.c. Pref. ...	112–117	...	...
1,392,220	"	Mar. 5	7	7	Wandsworth Consolidated	156–161	...	158–160
1,096,373	"	"	5	5	Do. 5 p.c. Pref.	119–124	...	124–123½
1,317,964	"	Dec. 18	5	5	Do. 5 p.c. Deb.	122–127	...	123½–125½
158,400	"	Mar. 5	5	6*g*	Winchester W. & G. 5 p.c. Con.	115–120	...	...

Quotations at:—*a.*—Bristol. *b.*—Liverpool. *c.*—Nottingham. *d.*—Newcastle. *e.*—Sheffield. *f.*—The quotation is per £1 of stock *g.*—Paid £8, including 10s. on account of back dividends. * Ex. div. † Paid free of income-tax. ‡ For year.

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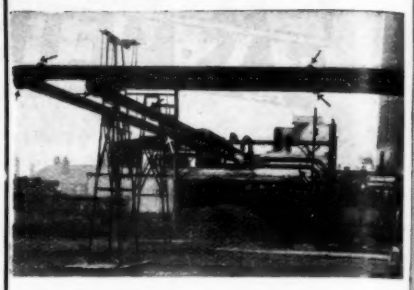
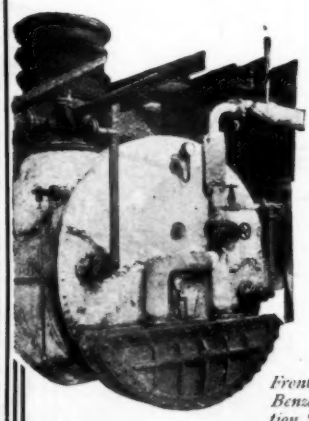


Two Steam Mains, one at a Pressure of 170 lbs. per square inch, the other at 20 lbs. per square inch.



Front View of Benzol Rectification Still. Pressure on Steam Chest, about 80 lbs.

These photographs show part of a Coke Oven Plant in a large Gas Works. Here again, "Permac" metal-to-metal jointing material has succeeded when more expensive jointings have failed.

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